Compressed Air Magazine

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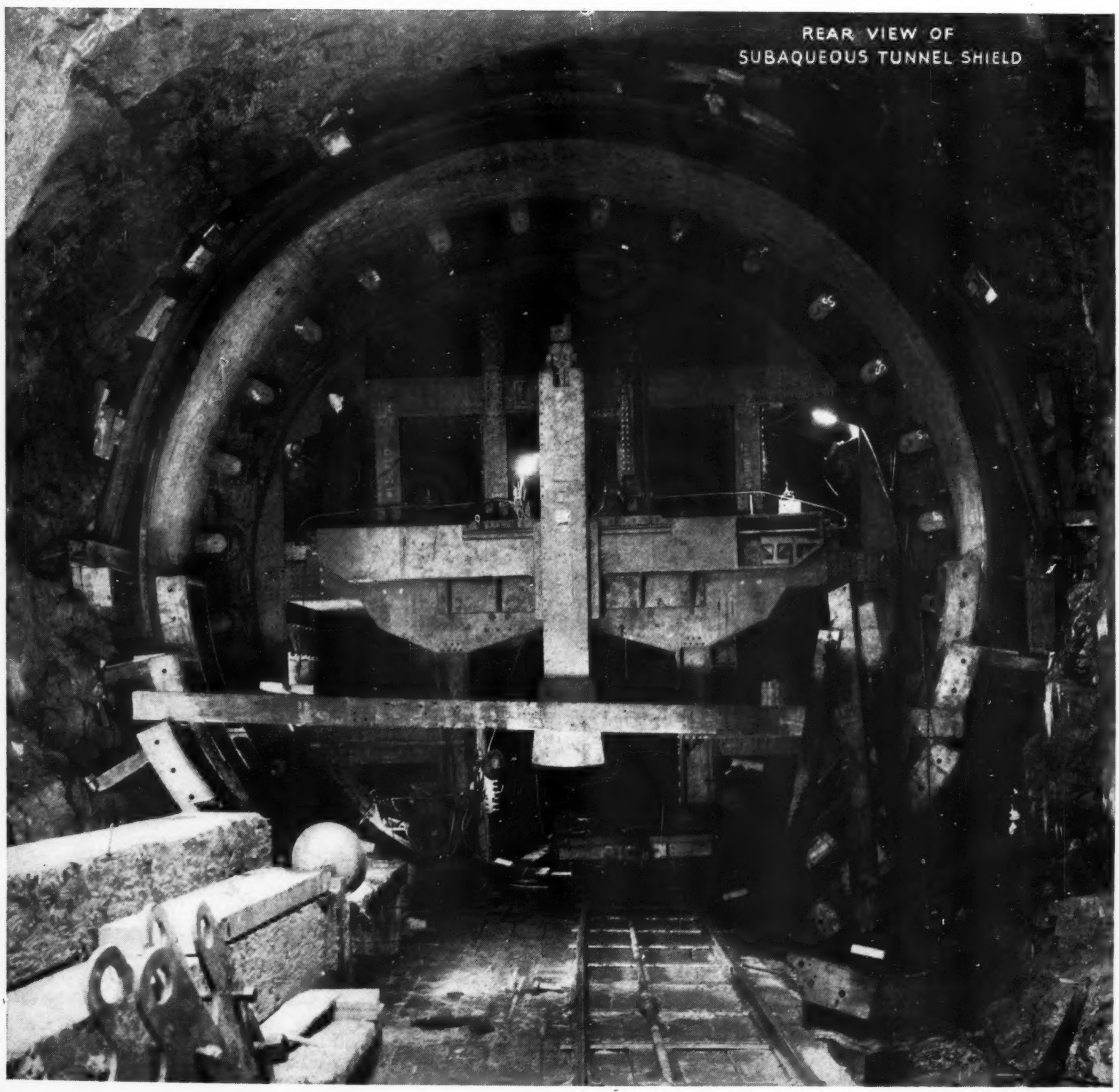
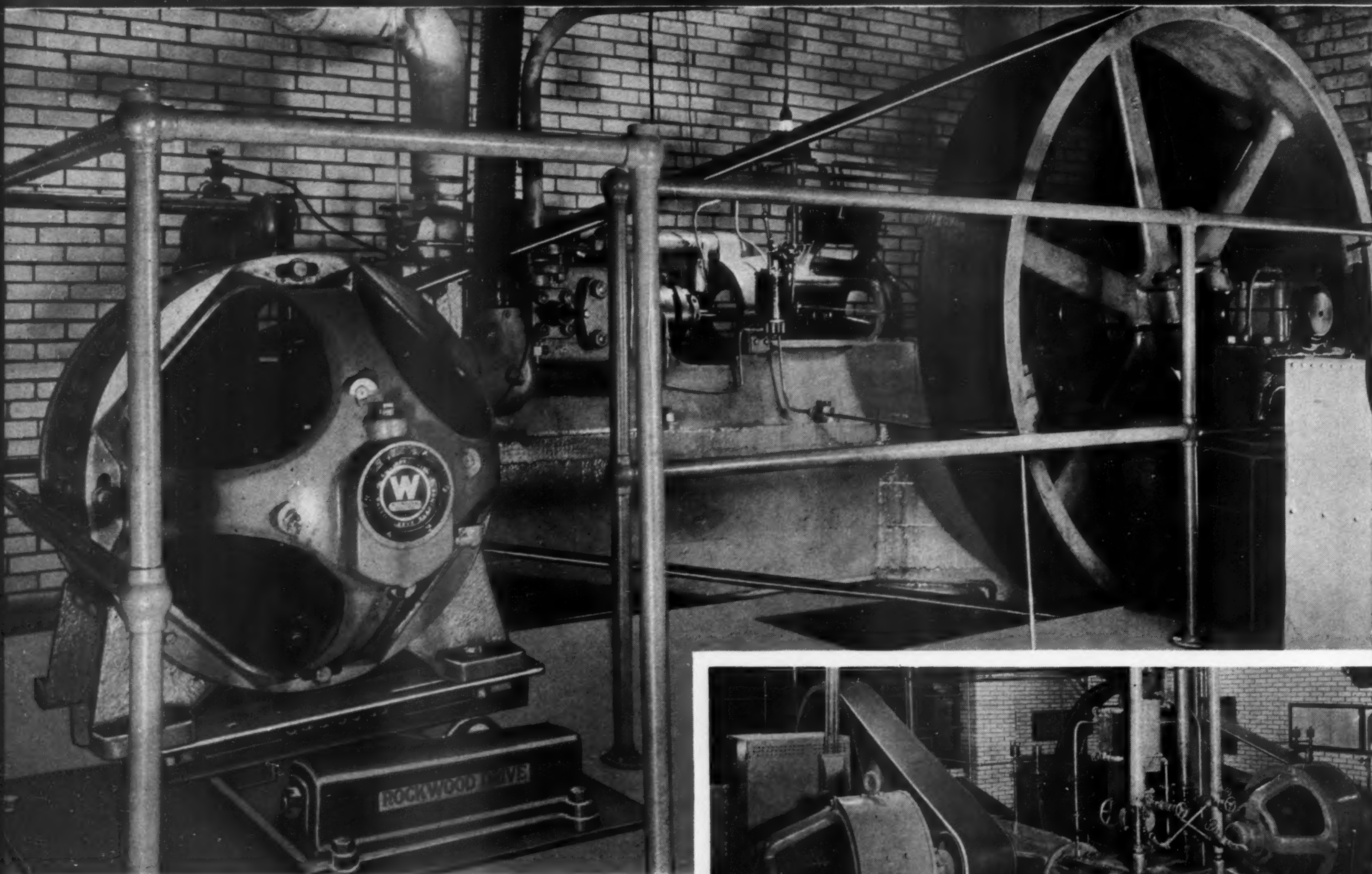


Typical Rockwood Drive Performance



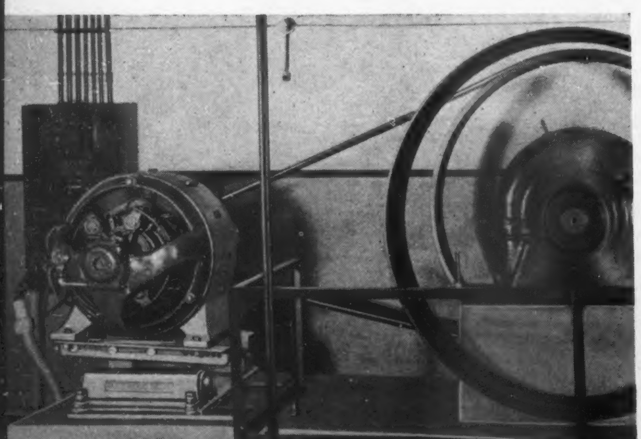
HOTEL DORSET, NEW YORK CITY has two 50 h.p. compressors driven by Rockwood pivoted-motor Drives. The compressors run better, the belts last longer, power is saved and there is almost utter freedom from the annoyance of drive attention.

HOTEL TAFT, NEW YORK CITY, has a Rockwood Drive to an ammonia compressor with a 37½ h.p., 350/625 r.p.m. motor, weighing 3,750 lbs. Installed in 1934 a satisfactory, dependable drive that costs less to operate.

ROCKWOOD
PIVOTED MOTOR DRIVE

Insist on having a Rockwood Drive with your new compressor.

Greatly Increased Drive Capacity--More Dependable Compressor Performance-- Longer Belt Life.



COMMODORE HOTEL, NEW YORK CITY, has this dependable 35 hp. Rockwood Drive to an air compressor. No more belt trouble, bearing trouble or drive trouble for them.

Only with a Rockwood pivoted base under the motor will your compressor operate continuously to maximum capacity and with lowest power consumption. The pivoted-motor base **automatically** takes up belt stretch, prevents excessive belt slip, saves power, and keeps the compressor always **up-to-speed**. Belt life, with either flat belts or V-belts, is often doubled. The saving in power due to higher sustained drive efficiency usually will pay for the drive in the first year.

The improvement in compressor performance and the reduction in operating costs and maintenance are startling. HOTELS—INSIST ON HAVING ROCKWOOD DRIVES WITH YOUR NEW COMPRESSORS. The improvement in compressor performance and the reduction in operating costs and maintenance are so startling. INSTALL A ROCKWOOD DRIVE TO YOUR OLD COMPRESSOR AND IMPROVE ITS PERFORMANCE. AT THE SAME TIME REDUCE YOUR POWER COSTS.

Write us for a recommendation. Every Rockwood Drive is guaranteed to be satisfactory or we don't want you to keep it. *We have a stock size Rockwood pivoted base to fit any stock size motor and can make deliveries immediately.*

Rockwood Manufacturing Company—*Indianapolis, Indiana*

Engin. Wilson 11-7-39

ON THE COVER

THIS huge shield is one of four identical units that constitute the spearheads of the subaqueous tunneling operations beneath the East River in New York City. Each shield is about 32 feet in diameter and weighs 400 tons. The erector arm that handles cast-iron lining segments is shown in a vertical position. Arranged in a circle near the outer rim are 28 hydraulic jacks by which the shield is shoved ahead periodically. This picture shows the shield starting through rock on its journey underneath the river. The outer shells of the four shields will be left where the two bores meet.

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IN THIS ISSUE

IT IS difficult to keep a fast-growing boy in clothing that fits him. Similarly, when a city expands as rapidly as has Corpus Christi, Tex., the problem of keeping its utilities abreast of its size becomes a serious one. It speaks well for the officials of Corpus Christi that they have been able to pace the enlargement of the water-supply facilities with the city's rate of growth, thereby averting any acute shortage. Our leading article describes the latest steps taken in this direction.

•

THE tunny, or tuna, as it is commercially known in this country, is one of the most popular fishes that come to us in cans. Behind every tin of it there is stirring adventure, as *The Romance of Deep-Sea Tuna* discloses.

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READERS of this magazine are somewhat familiar with the important rôle the airplane has played in developing the mineral outposts of Canada. Curiously enough, through aerial passenger service in the country has been late in coming; but it will soon take its place among the world's leading airlines. E. L. Chicanot tells how the transcontinental system was built up.

•

IT IS reported that New York City felt its first pangs of congestion in 1803. Periodically since then its transportation system has suffered from growing pains. As surface traffic could be speeded up only a certain amount, relief was obtained by elevating some of the trunk street railways. In 1904 the first subway line was opened, and since then there has been much underground and underwater burrowing. The first tubes were for rail traffic only; but as automobiles grew more numerous, the Holland vehicular tunnel was thrust beneath the Hudson River and became so popular that the Lincoln tubes were built under the same waterway. Now the $58,000,000 Queens Midtown twin tunnels are being constructed under the East River.

Compressed Air Magazine

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EDITORIAL CONTENTS

ADVERTISING INDEX

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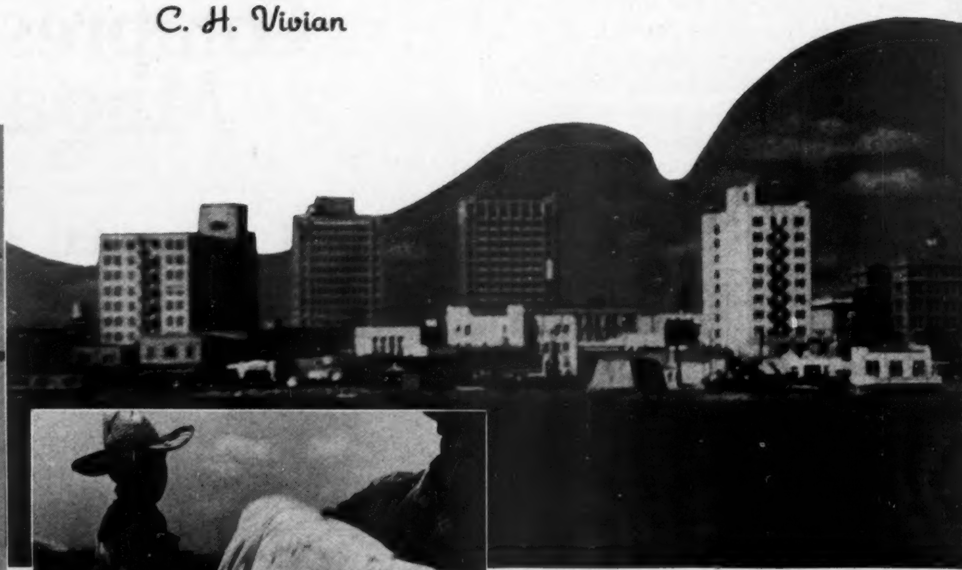
Corpus Christi Obtains More Water

C. H. Vivian

Corpus Christi Chamber of Commerce Photos



RICH CORPUS CHRISTI

Despite its mushroomlike growth, Corpus Christi is building substantially, as the view of its skyline from the harbor discloses. On three sides it is surrounded by what is known as black-hog-wallow land, a rich loamy soil that is highly productive. Nueces County, in which the city is situated, grows more cotton annually than any area of equal size in the country. The crop averages 90,000 bales, plus some 250,000 tons of cotton seed worth nearly $5,000,000. In addition, the county produces approximately 2,500 carloads of vegetables every winter, most of them for northern consumption. On the remaining side of Corpus Christi is the sea, where tarpon or other game fish may be caught during any month in the year. Nearby Bird Island is reputed to harbor more species of birds during the nesting period of April and May than any other plot of ground of the same size.

RECENT additions and improvements have given Corpus Christi, Tex., a municipal water-supply system that is considered one of the finest possessed by any community of its size in the country. The new work done included enlarging the filtration and treatment plant and laying 16 miles of 30-inch pressure pipe line from the plant to the city and 20 miles of distribution mains within the city limits. The last-mentioned operations are still in progress. The aggregate cost of all this will reach close to $1,000,000.

This revamping of the water-supply system has been made necessary by the almost phenomenal growth that Corpus Christi has undergone in recent years and is still experiencing. The city is at the southern end of a crescent-shaped section of the Gulf of Mexico coast which is enjoying real business and industrial expansion. This particular segment of the great State of Texas extends for approximately 250 miles, starting at Beaumont, to the north and east, and including Houston, which is now the largest city in the state.

Corpus Christi was discovered by the Spanish explorer de Pineda soon after Columbus made his first voyage to the western hemisphere. The name, meaning literally "Body of Christ," was given by him to the land-locked harbor in honor of a Catholic feast day. Just when the area was first colonized is not recorded; but for nearly four centuries it basked quietly in the warm sunshine of its semitropical climate, peopled largely by Mexicans and leading a somewhat somnolent existence. Gradually it gained favor as a fishing and recreation center and the rich soil of the surrounding region was put under cultivation. With the discovery of oil it awoke from its lethargy and was galvanized into activity.

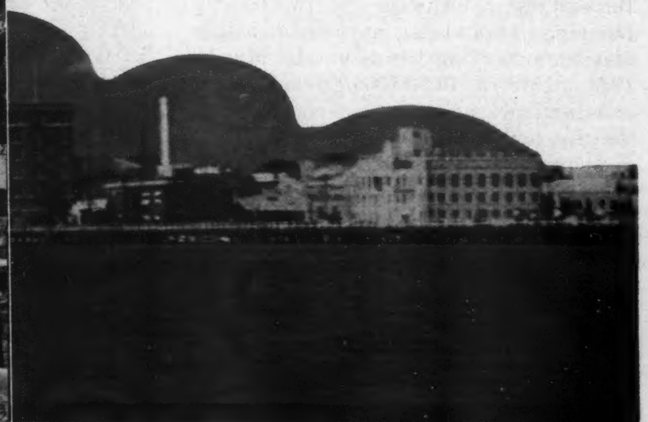
There are now more than 140 distinct and separate oil and gas fields within a radius of 125 miles of the city limits, and the number is increasing almost every month. Production, even though it is limited by proration, averages more than 120,000 barrels daily. A dozen plants for processing this oil have been established locally; but most of it is still moved to other points either through pipe lines or in ships. A 32-foot-deep channel that was dredged in 1926 makes the expansive harbor accessible to these tankers and to the numerous other vessels that call at the port.

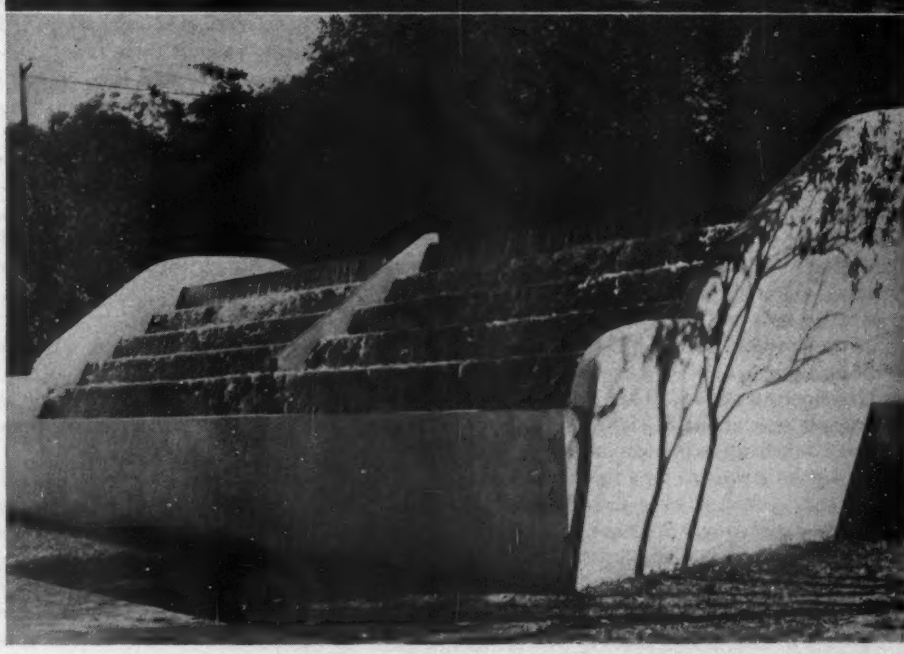
In point of value, petroleum accounts for the greater percentage of the commerce that passes through Corpus Christi en route to other parts of the world. Cotton, vegetables of all kinds, and cattle worth millions of dollars annually also contribute to the stream of maritime trade. Within four hours' drive toward the South is the lower Rio Grande River citrus-fruit district, and a large percentage of its produce is shipped by water out of Corpus Christi. Inexpensive fuel (natural gas may be obtained in unlimited quantities for five cents per 1,000 cubic feet), the superior transportation facilities, and other favorable factors are attracting industries to the region. The largest of these is the Southern Alkali Corporation which produces salt, soda ash, chlorine, and other chemical compounds from raw materials which are found within a radius of 60 miles.

Corpus Christi claims to be the fastest growing small city in the United States, and the available statistics would seem to indicate that it actually is. Official census figures show that its population increased from 8,222 in 1910 to 27,789 in 1930. The Chamber of Commerce places the 1939 population at 57,500, which represents a gain of more than 100 per cent in the past nine years. Postal receipts, the school census, and connections for the various utility services have doubled since 1930. Building permits are averaging more than $3,000,000 annually. Last year, 6,719,864 tons of water-borne freight was handled in the port. In view of the weed-like growth, it is not surprising that Corpus Christi has found it necessary to augment its supply of water.

CALALLEN TREATMENT WORKS

At Calallen, water is diverted from the Nueces River, is chemically treated, and pumped 16 miles into Corpus Christi. These pictures show the 8,000,000-gallon, concrete-lined coagulation basin (center below), the filtration building (left), and the specially designed concrete aerating tower (bottom) over which the water passes just before going to the filters.





Any well drilled in or near Corpus Christi yields salt water, oil, or gas—most likely one of the latter two. Lacking a source of potable ground water, the city derives its municipal supply from the Nueces River which empties into Nueces Bay a few miles to the northwest. The flow of the Nueces is very variable, ranging from a mere trickle during exceptionally dry spells to torrential floods at irregular but rather frequent intervals. The river and its tributaries drain an area of 17,000 square miles, which would be sufficient under ordinary conditions to insure a sustained flow. However, all the tributaries are crossed by the Balcones Fault, a great breach in the earth's crust that extends across a goodly portion of Texas and that has figured prominently in connection with the occurrence of oil and gas in numerous locations. In the southwestern part of the state the subsurface formations within this fault zone are cavernous; and when the streams are at the low-water stage, they simply disappear when they reach the fault. Accordingly, except when rains fall on the area downstream from the fault zone, there can be no dependable flow of the river.

To insure for itself a continuing supply of water in the face of such unusual circumstances, the City of Corpus Christi, in 1929, built a storage reservoir on the Nueces at Mathis about 30 miles upstream from the point where it debouches into the bay. Shortly afterward, the dam failed during a flood; but it was repaired in 1933. It is an earth-fill structure with a sheet-pile cut-off wall and a concrete spillway. It has sufficient capacity to impound 66,000 acre-feet of water. Water released from this reservoir flows down the river for a distance of 25 miles to a weir at Calallen, where it is withdrawn, chemically treated,

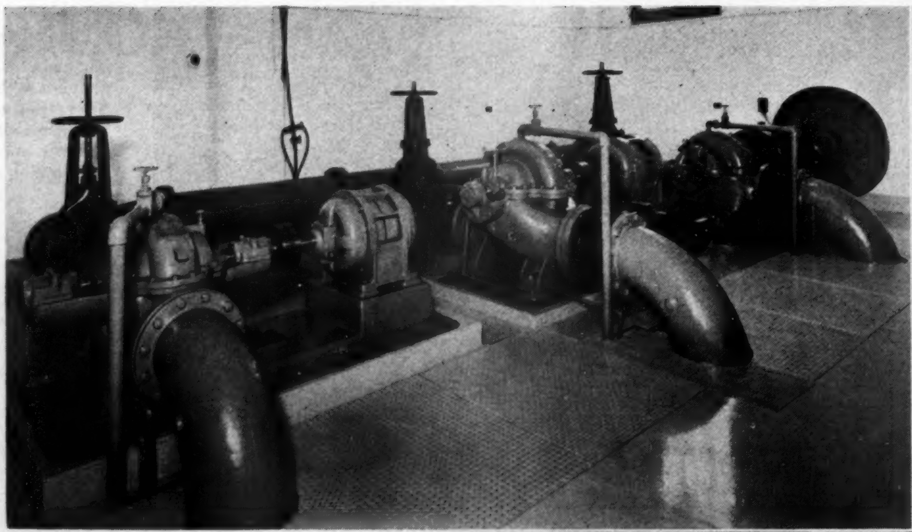
filtered, and pumped 16 miles into the city.

Prior to the recent improvements, the capacity of the treatment plant was 7,000,000 gallons a day. This has been increased to 18,000,000 gallons, and room has been provided for a further increase to 24,000,000 gallons. Formerly, the water was delivered from Calallen to Corpus Christi through one 20-inch pipe line, two booster pumping stations being employed to assure maximum carrying capacity. In March, 1938, a covered, 10,000,000-gallon storage-and-distribution reservoir was completed in the city, and into this, during off-peak periods, water was pumped in an effort to augment the supply. It was apparent, however, that the 20-inch line would soon be too small to serve the community's needs, and so a study was conducted with the result that it was decided to lay an additional 30-inch main from Calallen. This was done, and at the same time the pumping capacity at Calallen was increased sufficiently to permit eliminating the two booster pumping stations on the 20-inch line.

While Corpus Christi did not experience any real water shortage, nevertheless its plant was seriously taxed in meeting the demand when the new facilities became available for use. Today, the area within the former city limits is 80 per cent built up. Besides, approximately 2.4 square miles of territory has been added during the past few months, and this is about 50 per cent built up. The total municipal area now covers 13.4 square miles. During 1938 the volume of water pumped each day was from 1,000,000 to 1,250,000 gallons greater than that pumped on the corresponding day during the previous year. At the end of 1938 there were 7,573 water connections in the city, an increase of 585 during the year or nearly six times the number existing in 1920. The current daily consumption of water ranges from 4,000,000 gallons in the winter time to a summer peak of 10,000,000 gallons, while the average is around 6,000,000 gallons.

The designing of the new system and the directing of the construction work involved have been done on a coöperative basis by the city engineering department, headed by J. C. Bisset, and by a firm of consulting engineers, Myers & Noyes, of Dallas, Tex. The 30-inch pipe line was laid by the contracting company of Brown & Root, of Houston and Austin, Tex., on a bid of approximately $650,000. The plans for enlarging and modifying the treatment and pumping plant at Calallen were drawn up by Mr. Bisset and carried out by city forces working under John W. Cunningham, the water superintendent. This phase of the operations cost about $125,000.

The 30-inch main is composed of 81,936 linear feet of cast-iron pipe having a lining of cement ¼ inch thick. This piping was cast by the centrifugal process by the American Cast Iron Pipe Company of Birmingham, Ala., and, according to the latter, constituted the largest single order for pipe of that type and size ever placed in the United States. The rate at which it was produced and delivered was considered quite an accomplishment. The order called for 5,121 sections of pipe each 16 feet long. The contractor estimated that from 1,000 to 1,400 feet would be laid daily, which would require making and delivering 65 units a day. Actually, the mill started shipping on December 23, 1937, only seventeen days after the contractor's bond had been approved. From an initial production schedule of 25 pieces of pipe in eight hours, the output was steadily increased until it reached 55 in eight hours, or 110 pieces each 2-shift day. The final shipment arrived 30 days ahead of schedule. All pipe was tested by subjecting it to a hydrostatic pressure of 300 pounds per square inch. Out of every group of 350 pipes cast, one was tested to destruction. Only 55 pipes were scrapped as defective—a foundry loss of but 1.1 per cent.



No rock was encountered along the route followed, all excavating being in clay or sandy clay. A trench 48 inches wide was dug with an Austin trencher provided with 42-inch buckets with side cutters added. The main passes through three oil and gas fields and crosses 144 pipe lines ranging from 1 inch to 14 inches in size and carrying fluid under pressures up to 1,000 pounds. Highway-department records showed the locations of practically all these; but to obviate the possibility of rupturing unrecorded oil and gas lines, a special small trencher cut an 8-inch pilot trench ahead of the regular equipment. The pilot machine was fitted with an automatic trip that stopped it when it encountered any obstacle. As a result of the exercise of this precaution, only three small lines were broken, and none of these was under pressure.

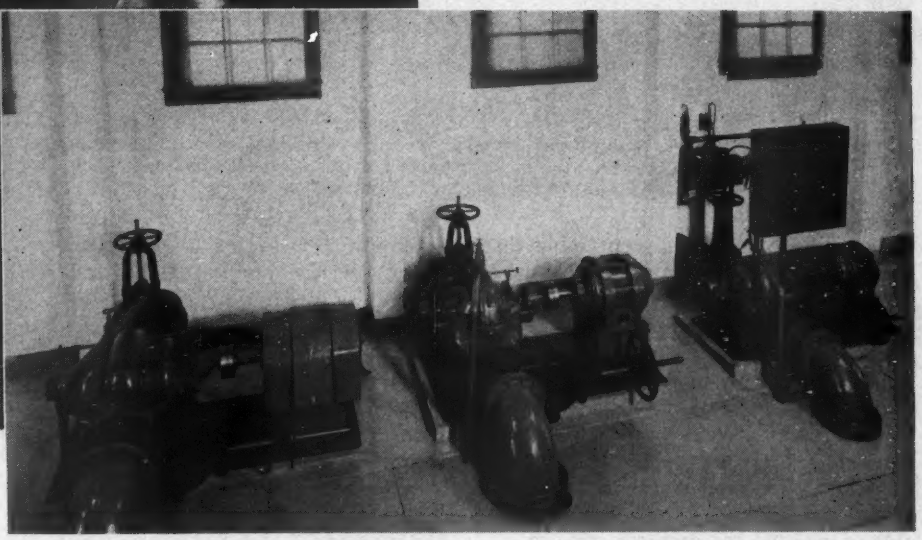
To give additional working room at each joint, the trench was widened on both sides with air-operated spades. The deepest cut was 10½ feet, and the average was 7½ feet, sufficient to provide for 4½ feet of cover. All the pipe was laid to line and grade. The ground surface in the area concerned is characterized by flatness, and there was a difference of only 61 feet in elevation between the low and high points of the line. No bends sharper than 45° were included.

The pipe is of the bell-and-spigot type, and joints were calked with cement, effecting a saving of approximately $28,000, as compared with the cost of using lead. Each unit was lowered into the trench by a Link Belt, 1¼-cubic-yard crawler-mounted dragline. When two adjacent pipe lengths had been loosely assembled, a piece of ½-inch braided jute rope was placed around the spigot, the joint forced home, and the pipe trued for line. The spigot was centered in the bell by joint-spacer chisels, and the jute was then calked into final position.

The calking mixture was made by adding barely sufficient water to Portland cement to permit the mass to be balled in the hand. Material of this consistency will shatter when dropped from a height of 6 inches or more. Enough cement was packed into each joint to fill half the available space. This was calked with hand hammers and calking irons, after which the remaining space was filled and calked in like manner. The calking crews worked about 100 feet back of the pipe-placing gangs, this interval being adequate to prevent any disturbance of finished joints. So far no leaky

PUMP ROOM AT CALALLEN

The three stages of pumping that are involved in sending the water through the treatment plant and then into Corpus Christi are handled by the ten motor-driven Ingersoll-Rand centrifugal pumps shown in the center. At the far end of the room, on the left, are the three first-stage units that pump water from the river into the coagulation basins. There is a closer view of these on the opposite page. Along the right-hand wall of the room are the three second-stage units (seen at closer range in the picture below) which pump the water from the coagulation basins over the aerating tower, from which it flows to the filters. In the foreground of the center picture are the four pumps that send the treated water through 16 miles of 20-inch and of 30-inch pipe lines into either a storage reservoir or elevated distribution tanks in the city.



joints have developed. Mechanical joints were employed at four points where the line crosses under railroads or highways, and at three of these locations the pipe was laid in concrete box culverts. Earth was backfilled into the trench by two machines and tamped by hand in 6-inch layers carried up evenly on both sides of the pipe to the spring line. Above the spring line it was tamped in 12-inch layers to a level 1 foot above the top of the pipe. The remainder of the backfill was not tamped, except in paved areas.

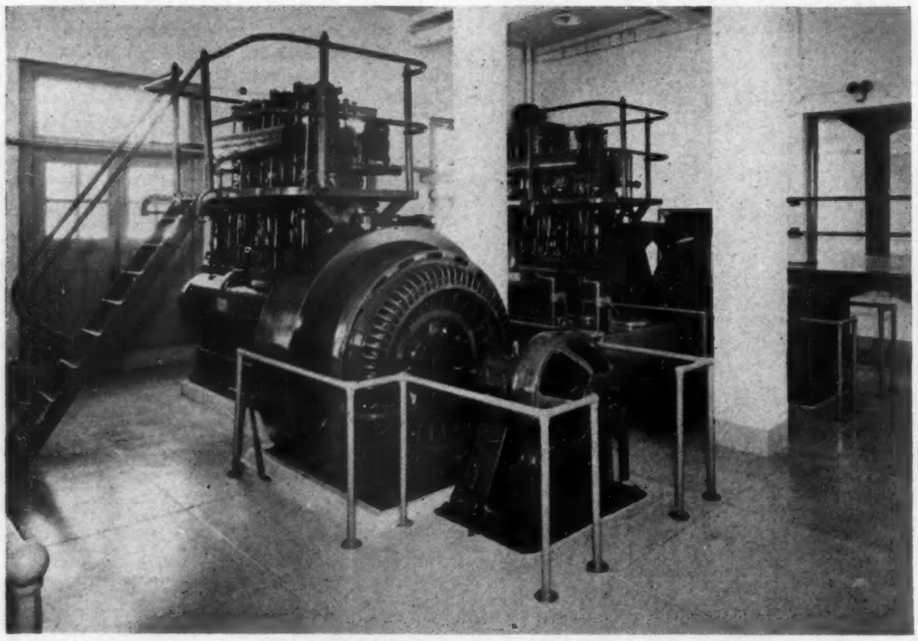
In making the required changes at the Calallen treatment and pumping station, costs were kept down by utilizing the foundations of the former sedimentation tanks in converting them into additional filters. To the six filters that were previously used have been added four units, making ten in regular service. Four more have been provided for and can be equipped in a short time when needed. In place of the sedimentation tanks, an 8,000,000-gallon, concrete-lined, outdoor basin has been built. This is divided in the center, making two 4,000,000-gallon enclosures.

In operation, water is pumped from the river into these coagulation basins. En route, lime and iron sulphate are added to it and it is prechlorinated. The basins are equipped with Dorr flocculators. After being allowed to settle in one basin, the water passes over baffles to the second one, and as it enters the latter it is treated with activated carbon and alum. From there it is pumped over an aerating tower of special design, whence it flows to and through sand-bottom filters. From the filters it goes into one of two clear wells which hold 500,000 gallons and 250,000 gallons, respectively. From the clear wells it is pumped into the city. Just before it reaches the suctions of the pumps it is given a final chlorination. Tests have shown that the water contains no trace of residual chlorine after flowing 3 miles through the pipe line.

The pump station at Calallen makes an unusually attractive appearance, as accompanying illustrations disclose. It houses ten Ingersoll-Rand Cameron centrifugal units, all motor driven and aggregating 910 hp. Records of the city show that, including those recently put in service, a total of 26 Cameron pumps has been purchased since the water works was established. The ten pumps are arranged in three groups, according to their service. In the first are three units with respective capacities of 2,200 gpm., 4,800 gpm., and 6,000 gpm. These take suction on the river and discharge into the coagulation basins. In the second group are three pumps having the same capacities as those in the first. These transfer the water from the coagulation basins to the top of the aerating tower. The third group consists of four units which deliver the water from the clear wells to the city. Two of these have a capacity of 2,250 gpm. each, and the other two of 2,600 gpm. each.

The pumps in the last group all discharge into a header that leads to a Venturi meter. Beyond the meter, the line divides, one branch going to the old 20-inch main and the other to the new 30-inch main. Ordinarily, both lines discharge in Corpus Christi into elevated tanks, one of 250,000 gallons capacity and the other of 500,000 gallons capacity. The full-surface level of these tanks is at Elevation 159. As the pumps are at Elevation 12, they operate against a static head of 147 feet. The combined static and frictional head is 202 feet.

As previously mentioned, a 10,000,000-gallon storage-and-distribution reservoir has been constructed in the city. It is



STANDBY GENERATING SETS

Each of these two Ingersoll-Rand Type PR oil engines drives a 100-kw. generator. When the pumping load was smaller, they supplied all the power required in the plant. They are now held for use in case of failure of central-station power.

served by a pump house containing three centrifugal motor-driven pumps having an aggregate capacity of 3,850 gpm. During periods of peak demand, the water is pumped from the reservoir to the elevated tanks. The supply in the reservoir is then replenished during the night when water consumption is low. To prevent the reservoir water from becoming stagnant, it is the practice to draw upon it each day, even though the two lines from Calallen are capable of meeting the demand.

As each section of the 30-inch main was completed up to a valve, it was put under hydrostatic pressure and tested. The water used for this purpose was sterilized and had lime added to it before it was admitted to the pipe at the Calallen plant. After being tested throughout its length, the line was flushed out and sterilized. It was put in service on May 12, 1938. The filling of the pipe required approximately 3,000,000 gallons.

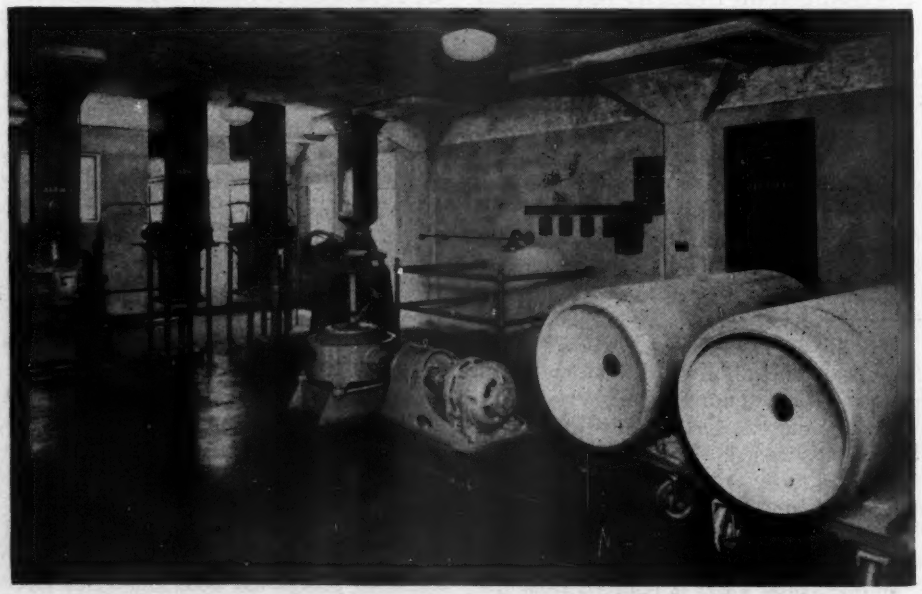
Distribution of water within Corpus Christi is by gravity pressure from the elevated tanks. The elevation within the city varies from sea level to 38 feet, and averages 22 feet. The average pressure of the water at the tap is 56 pounds per square inch. Fire plugs, having openings 5¼ inches in diameter, will deliver on an average 750 to 850 gpm. None discharges less than 600 gpm., and some test up to 1,300 gpm. The pressure of the city system does not have to be relied upon, however, for fire-fighting, as all the fire-department engines are equipped with high-pressure pumps.

As a result of these improvements, Corpus Christi has not only safeguarded its citizens against a possible water shortage for a number of years to come but it has also brought about a saving in unit pumping costs. Tests of the 20-inch line after 23 years of service showed that its friction factor had increased materially since the pipe was new. The use of the 30-inch main for handling the major portion of the supply has bettered this situation, while the elimination of the two booster stations formerly required on the old line has resulted in a direct power saving. It is estimated that the total power economy has been increased by 40 per cent.

Tangible evidence of the fact that the new system is worthy of the pride official and civilian Corpus Christi take in it is furnished by a letter received by Mayor A. C. McCaughan from the State Board of Health in February. This communication informed the city that it had been nominated to first place on the water-works honor roll in its district for the city including the greatest water-system improvement in its program during the past year, and also that it had been given honorable mention in the classification of cities having the best bacteriological record, based on the percentage of total samples submitted and a minimum of 48 samples.

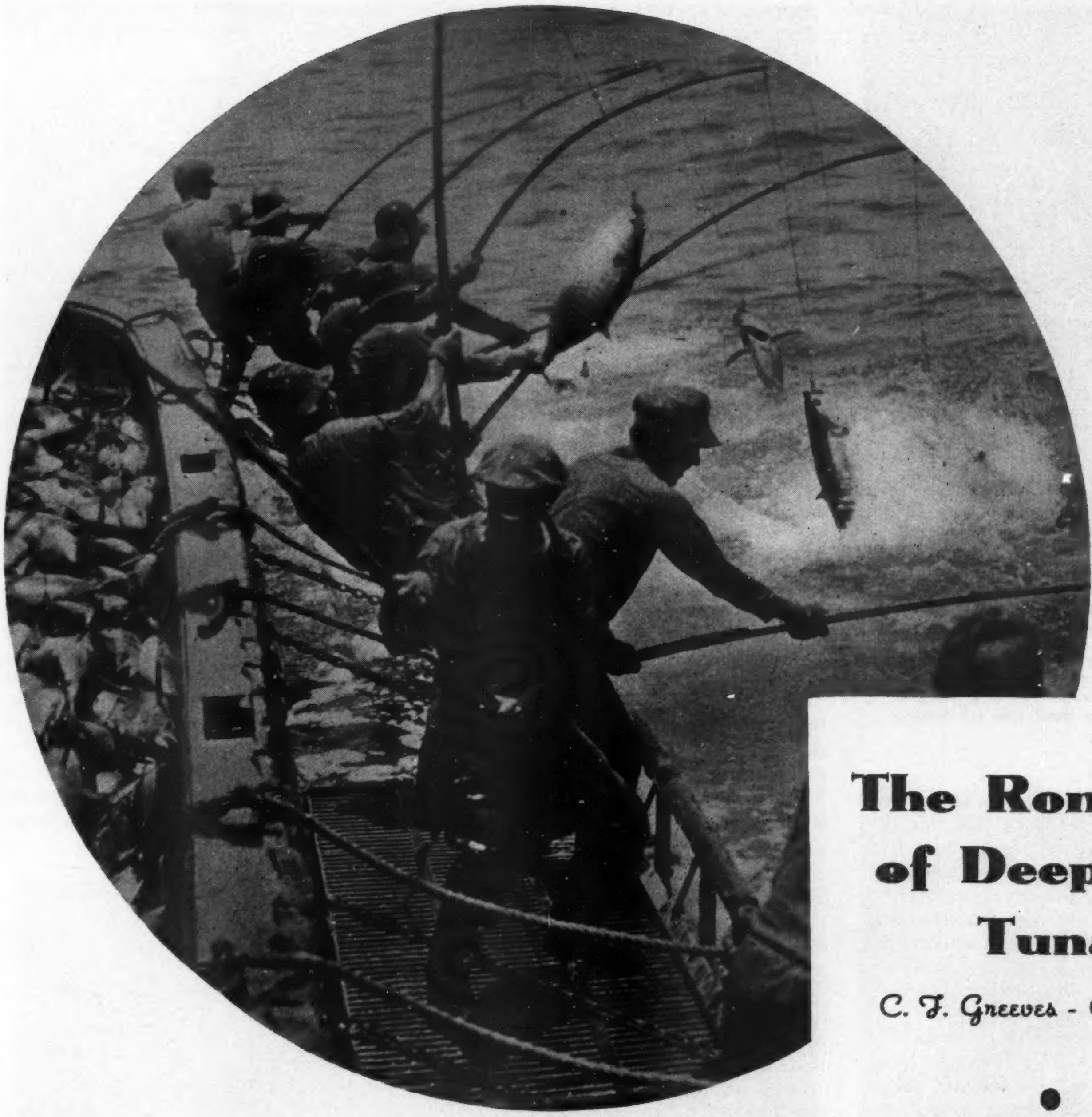
The work of laying new distribution mains is continuing, and will likely be in progress for some time to come, as building operations are steadily expanding the territory that must be served. These mains range up to 20 inches in diameter and consist of cast-iron pipe lined with cement and tar.

Meanwhile, a movement is underway looking towards systematic conservation and utilization of the waters of the Nueces River, and anything done along that line will benefit Corpus Christi by insuring a continuing water supply. This movement is being fostered by the Nueces River Conservation and Reclamation District, which was created by the Texas Legislature in 1935. Its president is O. N. Stevens, vice-president and general manager of the Southern Alkali Corporation. It has already succeeded in having extensive studies made of the problem by the U. S. Army Engineers and by Myers & Noyes, consulting engineers. A 4-point program of objectives has been drawn up, and it is expected that ways and means will be found to reclaim much of the run-off now being lost in the Balcones Fault Zone and to regulate the river for the benefit of irrigation and flood control through the construction of dams at strategic points.



CHEMICAL-TREATMENT ROOM

Alum and lime are introduced into the water in the desired amounts by the four vertical machines in the background. Chlorine is fed by the apparatus in the center. At the right are two flasks of chlorine, each of 1-ton capacity.



The Romance of Deep-Sea Tuna

C. J. Greeves - Carpenter

UNTIL comparatively recent times, tuna and tunalike fish abounded in the waters of the Pacific Ocean near San Diego, Calif. No expensive operations were then required to catch, to deliver, and to can these delectable fish, which have become a household delicacy. But suddenly, some thirteen years ago, the tuna departed for unknown places, and therein lies the story of the amazing development of the present tuna-fishing industry. Some of its phases, particularly the actual fishing, are truly spectacular. The following account pertains to the activities of the Van Camp Sea Food, Inc., well-known producers of tuna, sardines, and mackerel.

Prior to the disappearance of the tuna there was a demand for the palatable light meat which, unlike other fish products, is not strongly fish-like either in taste or odor. American housewives and chefs had discovered many appetizing ways of preparing canned tuna for the American table. A moderately large cannery had been established, and sales had been excellent. The tuna was the only fish that was canned without bones, although the bones are as edible as those in the best grades of canned salmon. Only selected light meat of uniform color and tenderness was retained for packing, the dark meat being used as a by-product. With the disappearance of the fish from the familiar waters, something had to be done. The market, once created, had to be maintained.

The then-existing tuna fleet was not suitable for the long-range cruising which the change made necessary. Larger boats had to be built. Designed to carry 30,000 gallons of nonexplosive diesel fuel oil, the new vessels have a cruising radius of 7,000 miles. They are equipped and provisioned to be away from their home ports of San Diego and San Pedro (Los Angeles Harbor) for three or four months, and each maintains contact with the home office by radio.

WHERE SPORT IS SERIOUS BUSINESS

Standing almost shoulder to shoulder on an outrigger platform, the crew works with feverish speed to catch as many tuna as possible before the school swims away. It requires great strength and skill to hoist these heavy, game fish on to the deck, especially where each man has but a few feet in which to work. Feathered, barbless hooks are used, and the fish shakes loose as soon as it is landed on deck. Eight trained fishermen can catch 20,000 pounds of tuna in an hour under favorable conditions.

The craft cost upwards of $100,000 each, and vary in length from 125 to 150 feet, with a 28-foot beam. Each has a capacity of from 100 to 350 tons of iced tuna.

Refrigeration naturally plays an important part, because the fish have to be kept in good condition for perhaps several weeks while the ship is at sea. Each boat formerly took aboard from 45 to 90 tons of ice. This

ROUGH GOING

When tuna are encountered, they must be caught, regardless of the weather. These fishermen take a bath every time the boat rolls, and are forced to hang on, leaving only one hand free for holding the rod.

was received in 300-pound blocks which were crushed on the dock. In this form the ice was blown into the holds by compressed air. This method of cooling was inefficient because the ice soon melted, so it was supplemented with mechanical refrigeration. Although it is still crushed and blown aboard, the ice is now prevented from melting by circulating ammonia through coils arranged in the holds.

Each vessel has two holds. The aft hold of the *Mayflower* is 13.5 feet wide and nearly 23 feet long, and the forward hold is approximately twice that size. Each craft is equipped with live-bait wells ranging in capacity from 30,000 to 45,000 gallons of sea water which is automatically pumped in and out so that the bait may be kept alive indefinitely. And now let us in imagination proceed to sea on a tuna-fishing expedition. We'll have to settle all our affairs ashore, for we may be away as long as four months.

Leaving port, the boat heads south, following the coast line of Lower California to Magdalena Bay, for the bait tanks have to be filled with sardines and anchovies before proceeding in quest of tuna. The small fish act as decoys, as will be seen later. On arriving in southern waters, the ship cruises about at night with all lights dimmed. At half speed, she rocks gently from side to side in the slight swell. There is almost complete silence aboard; and only the lapping of the water against the hull and the swaying of the vessel give one a sense of motion.

The lookout man searches the sea for the phosphorescent patch that indicates the presence of a school of small fry. As soon as such a patch is sighted, the speed is still further reduced, and the boat proceeds to encircle the scintillating area, while an 1,800-foot net is paid out over the stern as noiselessly as possible. When the school has thus been completely surrounded, the engines are stopped while the net with its precious catch is pulled on board and the thousands of squirming fish are transferred to the live-bait tanks. Perhaps the school has not been large enough to fill the tank completely. If that is the case, the ship continues its night maneuvers until more of the small fish are caught.

With the bait tanks full, the vessel heads toward the tropics in quest of tuna. At full speed she searches the waters of the southern latitudes, sometimes going as far south as Colombia. With the lookout posted in the crow's nest, the craft cruises about under the tropic sun by day and in view of the Southern Cross by night. Then, suddenly, a school of tuna is sighted. Diving in and out of the water, they are interesting to watch; but the lookout has no time to take in the beauty of the scene. Immediately his cry of "Tuna! Tuna"! electrifies everyone aboard into action. The "chummer," as the man in charge of the live bait is called, makes ready to release the small fry, while the fishermen rush to get their short, stout rods. These are about 8 feet long, and the lines are of the same length. No bait is used in tuna fishing. Instead, a lure, which generally consists of a barbless hook covered with feathers, is employed.

As the vessel approaches the school, the live bait is released, and the sardines and anchovies rush away as though glad to be out of their cramped quarters and back in the freedom of the open sea. The tuna see them, and immediately head toward the ship and the impending meal. The little fish, however, sense the approaching danger, and the majority of them turn back toward the boat as if seeking its protection As decoys they have served their purpose.

Now comes the real hard, fast work of catching the tuna. A crew of eight men can haul in 20,000 pounds in an hour if the school is a big one. If the fish are small—that is, are not more than 30 pounds apiece—each is caught by one man using a single rod and line; but if they weigh from 30 to 60 pounds, then two men and two poles are required to land each one of them. In that case the lines are joined two-thirds of the way down so as to form a single line from that point to the hook. Still larger fish, up to 150 pounds (tuna bigger than that are protected by law), need the concerted action of three men and three poles to get them successfully on deck—the three lines being caught together in one, as just described.

In fishing, the men keep the heads of the tuna up so that they can be easily hauled in and to avoid accidents. Upon

PAYING OUT THE BAIT NET

Before you can catch tuna, you must have a supply of small fish to serve as decoys. These are caught at night and by encircling a school of them with a net 1,800 feet long. They are kept aboard in special bait wells until a school of tuna is sighted, when they are released to attract the quarry to the side of the boat.

CLEANING PREPARATORY TO COOKING

Thanks to refrigerated boats, the tuna are delivered to the cannery in prime condition. After the viscera are removed, the fish are placed in roller-mounted racks to be wheeled into steam cookers. As shown here, large tuna have to be cut up to get them into the trays.

touching the deck, the tuna shakes its head, and the hook, lacking a barb, is disengaged, whereupon it is immediately returned to the sea. As soon as the line strikes the water, another tuna is caught, and fishing continues with back-breaking celerity until the boat is loaded to the gunwales or until the school suddenly and mysteriously disappears. Sometimes fishing does not follow the prescribed procedure. If a tuna manages to get its head down, then woe betide the luckless fisherman who doesn't cut the line in time, for one flip of the creature's powerful tail will send the tuna deeply into the water with fisherman, line, and all following in its wake. As the waters are infested with man-eating sharks, such an immersion sometimes has a sad ending.

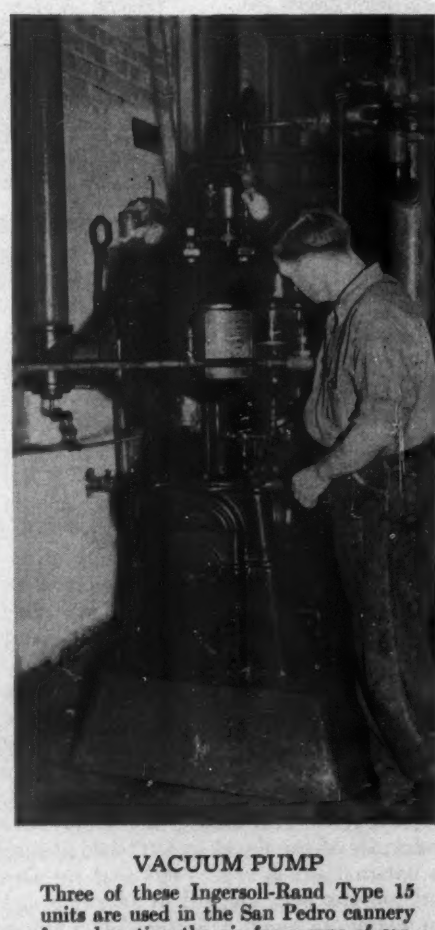
If the school persists in chasing the live bait and the decks are loaded to capacity, the skipper halts operations just long enough to stow and ice the catch below in the holds. First comes a layer of ice, then one of tuna, another of ice, and so on. While this change of work breaks the routine somewhat and gives relief to aching muscles, there is still need for haste so that the decks may be quickly cleared and fishing resumed. Once the school disappears, it may take days of cruising before another is sighted; but as soon as the holds are full, the vessel proceeds toward her home port in California, and as speedy a run as possible is made to one of the company's canneries which are located on wharves in the harbors of San Diego and San Pedro.

As each vessel is berthed, her cargo of iced tuna is loaded into slings, hoisted from the holds, and delivered to endless conveyors which transport the fish to the cannery. If they are frozen, they are first thawed and the viscera are removed. Next, they are placed on large roller-mounted racks ready for wheeling to the steam boxes which, in the San Diego cannery, are of sufficient capacity to cook 100 tons of tuna at a time. They are cooked by steam at 10 pounds pressure and at a temperature of 218°F. for a period of from two to six hours, depending upon the size of the fish. The tuna are then cooled overnight in a room that is ventilated by a series of fan blowers which are arranged so as to circulate the air through the racks. This first cleaning and cooking results in a loss of weight that is equivalent to about a third of that of the catch.

Following these operations, the tuna are subjected to a second cleaning. Women remove the heads, take off the skin, open up the fish, and take out the dark meat and bones. Only the finest edible part of the light meat is left for canning. This is thoroughly inspected and put on trays on which it is passed to the automatic slicing machine which cuts it into portions that will fit into the cans in which it is packed.

The original cooking removes from the tuna all the natural fish oil, which accounts for its lack of the strong, fishy flavor that is characteristic of some canned seafoods. As a result, when the tuna is packed in the cans it is quite dry, so each is filled with a high-grade salad oil consisting of cottonseed oil seasoned with salt. The cans are next passed through an "exhaust box" and then to an automatic capping machine. In the exhaust box they are heated by steam coils, the heat serving to attenuate the air in the cans and thus to produce a partial vacuum in them after they are sealed and cooled. The packed cans are thoroughly washed, rinsed, and loaded on to racks for transfer to large steam retorts where they undergo sterilization cooking before being shipped for marketing in stores throughout the United States.

Some of the tuna that is not canned is dried, the oil is pressed out and the residue is ground and sold as fertilizer. The oil is used extensively by paint manufacturers. As a matter of fact, the returns from these by-products contribute appreciably to the net profits of the business. Tuna fishing has become a large industry within recent years. The total pack rose from 100,000 cases in 1912 to 3,500,000 in 1937. This growth is positive proof of the popularity of this delicacy, which the Van Camp organization advertises as "chicken of the sea."



VACUUM PUMP

Three of these Ingersoll-Rand Type 15 units are used in the San Pedro cannery for exhausting the air from cans of sardines preparatory to sealing them. A lower vacuum suffices in packing tuna, and this is obtained by passing the open cans through a steam-heated exhaust box, the heat serving to attenuate the air.

Spanning Canada by Air

E. L. Chicanot

A PLANE OVER VANCOUVER

Vancouver is 2,411 air miles from Montreal. A round-trip flight between the two points can now be made in less than 36 hours, which represents a saving of six days compared with the fastest land service.

LOADING EXPRESS

In addition to its passenger-carrying capacity, each plane has room for 2,700 pounds of mail and express.

BEFORE the end of the summer, Canada's Atlantic and Pacific seaboards will be linked by an uninterrupted mail-and-passenger air service. Already it is possible to board a plane in either Montreal or Toronto and reach Vancouver in a little more than sixteen hours. In other words, one may dine today in the Metropolis or Queen City and lunch tomorrow on the Pacific Coast. Because of favorable winds, the return flight can be made about two hours quicker.

In many ways this marks a climax in aeronautical development in the Dominion, though it may scarcely be appreciated by those to whom transcontinental air travel has become familiar and routine. Canada, it is true, is late among the progressive countries of the world in establishing such a national airway. It is not that the Dominion has been laggard in adopting and unfolding an aerial program; but a transcontinental airway has had to wait upon more immediately pressing demands.

Commercial air development in Canada took a northerly direction rather than an east-to-west one, and bridged the distance between civilization and the wilderness instead of linking up the principal centers of population. When, in 1923, a trio of ex-air-force aviators organized the first commercial air service between the frontier and a newly discovered copper-gold deposit in the hinterland, they wrote the first paragraph to a glowing chapter in the annals of aviation. Since then, multiplying lines have struck northward to take the amenities of modern living to that vast raw land and to lend their aid to the exploitation of its rich natural resources. Their accomplishment is reflected in the number of producing mines that dots the otherwise inaccessible territory and in the freight of metals, fish, peltry, and other products borne out of the area in routine fashion.

All the while, however, the Canadian government had in contemplation the possibility of a transcontinental air service bringing the two distant coasts closer together. It was, for the main part, content to leave the development of intercity transportation in abeyance until progress elsewhere gave a clearer indication of its value. The success of such lines in Europe and in the United States decided the government to lay out plans looking to the joining up of the country's principal centers by air from coast to coast.

As a step in establishing a chain of airports across Canada, and also towards providing the necessary personnel, the government in 1927 launched a flying-club movement with the offer of grants and gifts of aircraft. During the next two years 23 such clubs were organized in the leading cities; and airdromes constructed by them or by the municipalities with government assistance formed the nucleus for the transcanada airway. As a further aid, the government undertook to provide intermediate landing fields and to assume the responsibility for weather reporting, lighting, and radio services.

By the end of 1929 the prairie section of the transcanada airway, the one presenting the least difficulties to development, was in complete operation with a chain of lighted airdromes and mail being regularly flown between Winnipeg and Edmonton via Regina, Moose Jaw, Medicine Hat, Lethbridge, and Calgary, as well as Regina, Saskatoon, and North Battleford. This was maintained until April, 1932, progress being made the while on other sections of the projected airway. Then the depression necessitated temporary suspension of this service. Surveys, however, were continued with a view to its eventual completion from coast to coast, and the private lines increased their indispensable work beyond the frontiers.

When, a few years ago, the government decided the time was opportune for resum-

WINNIPEG HANGAR

Winnipeg, midway between Montreal and Vancouver, is the headquarters of operations, and provides unsurpassed facilities for testing engines. The company has standardized on Lockheed all-metal, 17-passenger, 2-motored machines, of which fifteen are in service. They have a top speed of 264 miles an hour and a cruising speed of 200 miles an hour.

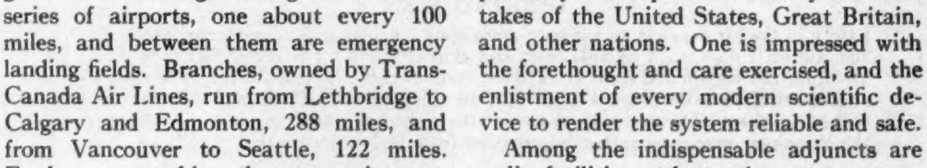
ing its national airway program, the country could point to a record of accomplishment in aviation that was outstanding. There were no less than 30 commercial aviation companies in existence, and they were transporting more freight by air than was any other country—in fact, they were annually moving more than the combined plane services of the United States, Great Britain, and France. Those companies, together with the flying clubs, have developed an elaborate personnel under flying conditions that are considered to be the most rigorous on earth. There were several adequately equipped airports between Montreal and Vancouver; one section of the transcontinental route had been successfully proved and flown; and much valuable survey work had been conducted on the others.

Actual provision for the establishment of a transcontinental airway was made in April, 1937, by an act of Parliament, which arranged for the coöperation of the government with a company that was to be incorporated. That was the Trans-Canada Air Lines, capitalized at $5,000,000. It was stipulated that the majority of the stock must always be held by the Canadian National Railways, which, as a matter of fact, is now the only stockholder. Maintenance and operation of the airway is therefore essentially a government enterprise effected through a partnership between the Department of Transport, the Post Office, and the government-owned railroad.

This partnership act has already developed a transcontinental air route extending from Moncton, N. B., to Vancouver, B. C., a distance of 3,118 miles, passing through Montreal, Ottawa, Toronto, North Bay, Kapuskasing, Wagaming, Winnipeg, Regina, and Lethbridge. Along this route is a series of airports, one about every 100 miles, and between them are emergency landing fields. Branches, owned by Trans-Canada Air Lines, run from Lethbridge to Calgary and Edmonton, 288 miles, and from Vancouver to Seattle, 122 miles. Feeders, operated by other companies, connect the transcontinental airway with other important communities, creating a considerable network. These are naturally expected to increase in number, and the prospects are that lines running from the Canadian transcontinental system will be linked with United States air routes.

It was Canada's determination from the first to establish a national air service comparable to that of any country; and by coming a little late into the intercity field the Dominion has of course been able to profit by the experience and by the mistakes of the United States, Great Britain, and other nations. One is impressed with the forethought and care exercised, and the enlistment of every modern scientific device to render the system reliable and safe.

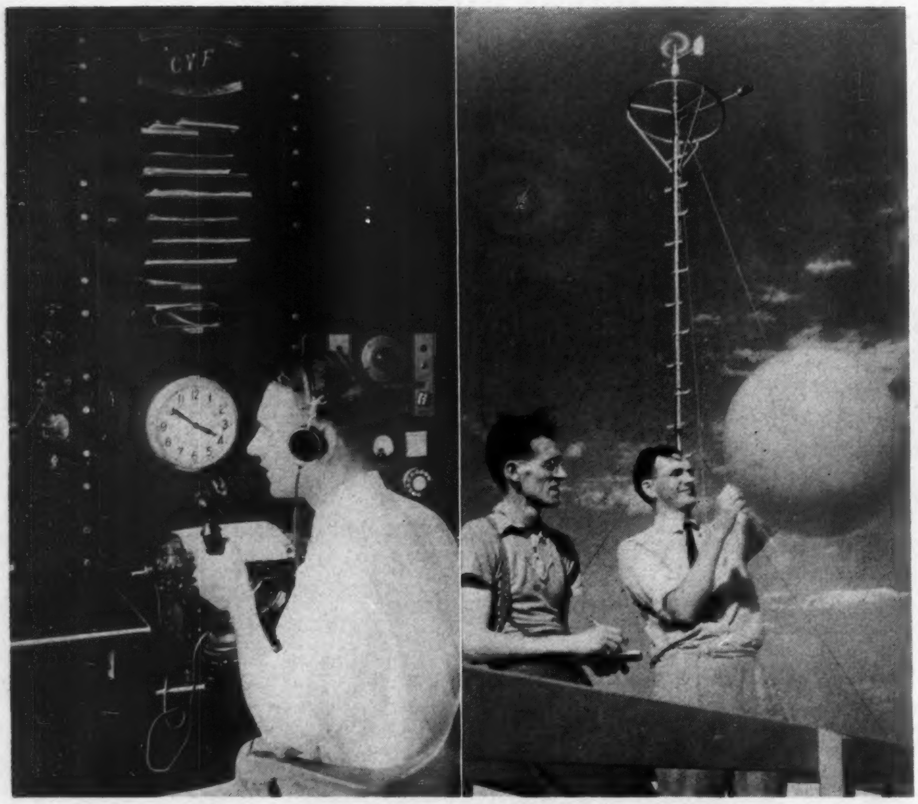
Among the indispensable adjuncts are radio facilities and an adequate meteorological service, which has been part of the responsibility of the government's Department of Transport. The radio ranges are the most modern available, and the system of weather observation, forecasting, and dissemination is surpassed nowhere. Forecasting centers are at Vancouver, Edmonton, Lethbridge, Winnipeg, Kapuskasing, Toronto, and Montreal. These observe, analyze, and report on conditions 24 hours a day, seven days a week. They are interconnected by teletype circuits, while serv-



Adapted from "Canadian Aviation"

HOW FLYING HAS NARROWED CANADA

The large map shows the principal cities that will be served by Trans-Canada Air Lines. Scheduled flights between Montreal and Vancouver were started on April 1, and by summer the country will be completely spanned. When this is achieved, the transportation time from Moncton to Vancouver by air will be one-sixth that of the fastest railroad time. This sixfold reduction in the breadth of Canada is shown, comparatively, by the small map in the inset.



GROUND MEN

Safety in the air depends as much or more upon efficient ground personnel and scientific aid as it does upon reliable craft and skillful pilots. The dispatcher (left) is an all-important person and must be capable, cool-headed, and resourceful. The meteorological staff likewise plays a vital part in bringing aircraft through on time and without mishap. The two men shown at the right are about to release a balloon at the Winnipeg airport to gather information for pilots as to weather conditions aloft.

ices of a similar nature to the south are made available through arrangements with the United States and to the north by the Department of Transport's own stations.

When the Trans-Canada Air Lines set out to establish a transcontinental system, it faced three main problems: the purchase of adequate equipment; training of the necessary technical personnel; and the development of facilities. With the material that it had to work upon it has been possible to furnish all these in two years and to put the service in operation. After a thorough investigation, the company decided on the modern multi-engined, all-metal Lockheed plane, and obtained a fleet of fifteen. Each carries a crew of three—a captain and a first officer, both of whom are pilots, and a stewardess; has accommodations for ten passengers; and its cargo compartments are capable of carrying 2,700 pounds. It has a fuel capacity of 536 imperial gallons (643 U. S. gallons), a cruising speed of 200 miles per hour, and a maximum speed of 264 miles per hour.

The most difficult problem was the training of pilots, mechanics, radio operators, and other technical craftsmen, for even though Canada has developed airmen in her northern services comparable in most respects to any the world over, their experience does not qualify them for the specialized needs of a transcontinental mail-and-passenger line. As a first step, four specialists were engaged in the United States: a flying supervisor, capable of organizing a training program for instrument flying; an expert in aircraft and engine maintenance and overhaul; another in radio engineering; and a specialist in meteorology and dispatch as applied to scheduled transport operations. These appointments were temporary, the understanding being that Canadians would take over after the expiration of the development period.

Headquarters were established at Winnipeg, and a training school was set up in September, 1937. Pilots were picked from thousands of applicants for physical fitness, character, intelligence, and experience. One essential was that they should have thousands of flying miles behind them; and each man went into what has been termed the world's most intensive training course for pilots. Instrument flying, as practiced in the United States, was adopted; and pilots began with the Link Trainer which enabled them to simulate flying over courses without leaving the ground. Later they made experimental flights for months so that they would become familiar with the aircraft and the route they were to travel. When they actually started carrying mail and passengers it was an old affair to them.

Pilots depend entirely on instruments. Radio ranges are calibrated to create a continuous track or beam across the continent, so that the flier knows where he is all the time. Each plane is equipped with four radio receivers: One gives the pilot the beam signals; another direct voice communication with the earth so that he may get weather reports and other vital information; the third is a standby, for emergency use, and duplicates those just mentioned; and the fourth is a marker receiver that indicates the points at which it is safe to lose altitude in approaching a terminal. A 2-way radio-communication system maintains voice contact continuously between ground and plane and between ground stations along the entire route.

As flying aids, every modern device is being utilized. Each airplane is fitted with a gyro-horizon, which shows the pilot whether he is climbing, banking, gliding, diving, or flying level; a directional gyro, which indicates how straight a course he is flying and enables him to make turns without reference to the magnetic compass; a bank and turn indicator, which records the rate of turning and whether the plane is skidding or side-slipping; and a gyro pilot to fly the machine automatically.

As most airports are municipally owned and fully equipped with paved runways, radio range, light beacon, and boundary and runway lights, the Trans-Canada Air Lines made arrangements to use many of them. It erected its own hangars at Winnipeg, Lethbridge, and Toronto, and will provide similar structures at Montreal and Moncton. At Winnipeg is the test house for engines, ranked as one of the most modern on the continent.

At the end of 1938 the staff of Trans-Canada Air Lines numbered 330, and the company had flown nearly 2,000,000 miles in less than two years, crossing the continent in both directions every day, shuttling back and forth between Lethbridge and Edmonton, and making two round trips daily between Vancouver and Seattle. In March, 1938, night mail flights between Winnipeg and the Pacific Coast were inaugurated. Later in the year mail was carried between Montreal and Winnipeg, and shortly afterward the shipment of express matter was begun. In March, 1939, regular air-mail service between Montreal and Vancouver was started, and a month later daily passenger service between Montreal and the Pacific Coast.

The transcontinental airway of Canada is a great national achievement, but it is of more than national significance. It is regarded as a part of the elaborate network of British Empire air communications. During the coming summer the transatlantic flying boats of Imperial Airways will connect with Trans-Canada Air Lines at Montreal, and mail will be carried on to points as far as the Pacific. It is not difficult to foresee the next step—a similar transfer of passengers from Europe. And looking ahead, one can envisage Canada's transcontinental airline connecting at Vancouver with a transpacific service to Australia, New Zealand, and beyond, completing a line of Empire airways round the globe.

The Queens Midtown Vehicular Tunnel

J. D. Jacobs

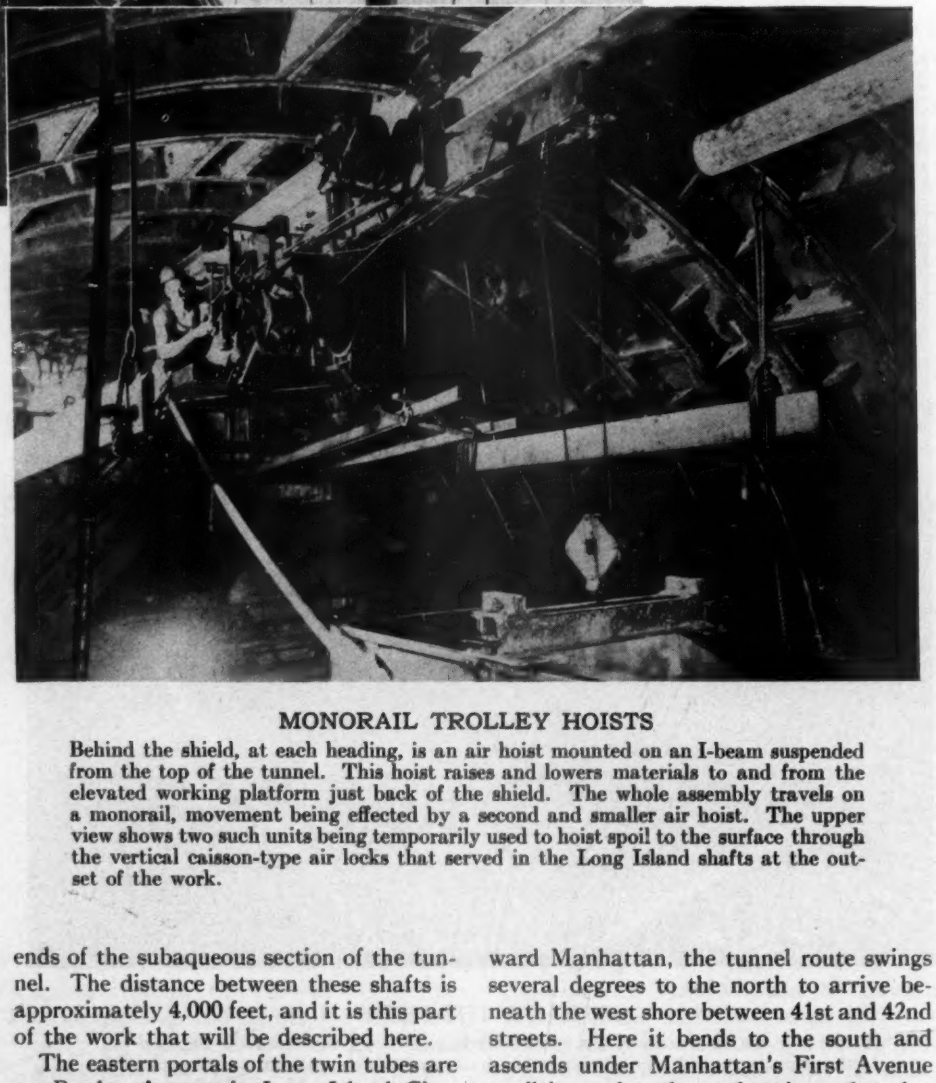
A NEW YORKER takes his tunnels for granted—underground transportation has become such a necessity in his daily routine that he seldom gives more than a passing thought to the engineering and construction marvels of a new undertaking of this kind. For nearly half a century he has watched the building of subsurface and subaqueous tubes, most of which, until twelve years ago, were for the use of subways and railroads. In 1927 he was given a new medium of transportation—the subaqueous vehicular tunnel. Since then, others have been constructed not only in congested New York but elsewhere in the nation and abroad. Before inspecting the Queens Midtown Tunnel, New York's latest vehicular-tube project, it may be well to consider briefly the geographical features which make it a necessity.

WITHIN THE BORE

At the top is a view toward the tunnel heading, showing the centrally disposed platform which is moved along behind the shield and which forms a working place for men injecting grout and performing other necessary tasks. Along the floor are two 36-inch-gauge railroad tracks for haulage. Pipes for conveying compressed air and high-pressure water to the face are arranged along the sides. The elevated walkway at the right affords an avenue of escape for the sandhogs should the workings be flooded. The erector arm mounted at the rear of the shield (bottom picture) is swinging into position one of the 1½-ton cast-iron lining segments. Fourteen of these, together with a keyway, form a complete ring 31 feet in outside diameter. Each time a ring is bolted to the preceding one, 32 inches is added to the length of the tunnel.

New York City is divided into five boroughs, all separated partially or completely by waterways. At the western edge of the metropolis is the Hudson River, across which are the busy neighboring cities of the State of New Jersey. Commercially, the heart of New York is the Borough of Manhattan, a finger-shaped island between the Hudson and that narrow ocean arm known as the East River. On the other side of the latter waterway and opposite downtown Manhattan is Brooklyn, another crowded center. On Long Island, to the north and east of Brooklyn and opposite midtown and upper Manhattan, is the Borough of Queens, which is rapidly developing into an industrial and residential section. Beyond Brooklyn and Queens lies the whole of Long Island, with its smaller towns and numerous country homes and summer communities, all of which demand rapid access to Manhattan.

In the early days, travel from Manhattan to either the Jersey shore or to Long Island was solely by ferry. With the appearance of electric railroads, the demand for quicker transportation led to the construction of the Brooklyn Bridge, which was opened in 1883 and was the first of the three suspension spans which link Manhattan and Brooklyn. Williamsburg Bridge was completed in 1904, and Manhattan Bridge in 1909. In the latter year the Queensborough Bridge from Manhattan to Queens also was placed in service. These structures were all built long before automobile traffic had become the problem that



MONOREAIL TROLLEY HOISTS

Behind the shield, at each heading, is an air hoist mounted on an I-beam suspended from the top of the tunnel. This hoist raises and lowers materials to and from the elevated working platform just back of the shield. The whole assembly travels on a monorail, movement being effected by a second and smaller air hoist. The upper view shows two such units being temporarily used to hoist spoil to the surface through the vertical caisson-type air locks that served in the Long Island shafts at the outset of the work.

it is today, and until the opening of the Triborough Bridge in 1936 offered the only vehicular roadways across the East River. For several years there has been increasing need for another transriver artery for auto traffic. The decision to construct this new crossing in the form of a tunnel was a logical one, considering the great success of the now famous Holland Tunnel under the Hudson, which was completed in 1927.

The Queens Midtown Tunnel project was made possible by the Public Works Administration through a loan of $47,130,000 and a grant of $11,235,000 to meet the total estimated cost of $58,365,000. Ground was broken by President Roosevelt on October 2, 1936. Present progress and schedules indicate completion in 1940. Engineering and execution of the undertaking are in the hands of the New York City Tunnel Authority.

The new tunnel—really two, one for eastbound and another for westbound traffic—will be slightly larger in diameter than the Holland Tunnel. Roadways will be 21 feet wide and will have 13½ feet of headroom. The interior walls and ceiling will be glazed tile, into which will be recessed the illuminating units and other facilities such as ventilation grilles and electric signal devices for traffic control. Fresh air ducts beneath the roadway slab and exhaust ducts above the ceiling will convey a continuous stream of air supplied by 46 blower and exhaust fans in two ventilation buildings, one on each side of the river at the ends of the subaqueous section of the tunnel. The distance between these shafts is approximately 4,000 feet, and it is this part of the work that will be described here.

The eastern portals of the twin tubes are on Borden Avenue in Long Island City, in the southwestern section of Queens, where high-speed roadways will be extended so as to connect with existing parkways and thoroughfares serving the outlying districts. Plunging under the East River toward Manhattan, the tunnel route swings several degrees to the north to arrive beneath the west shore between 41st and 42nd streets. Here it bends to the south and ascends under Manhattan's First Avenue until it reaches the surface in a plaza between 36th and 37th streets. This places the Manhattan end at a point directly across town from the entrance of the Lincoln Tunnel to New Jersey. The location and the designs of these entrance plazas of

the Queens Midtown Tunnel fit into a plan for a future vehicular tunnel under Manhattan to link the two, thereby forming a direct connection between Long Island and New Jersey and eliminating the heavy cross traffic which is encountered on any existing surface route in traversing that part of the city.

Motorists using the Queens Midtown will observe little to distinguish it in appearance from the Hudson River vehicular tunnel. Considered from the builder's viewpoint, however, it differs decidedly from its predecessors, because, geologically, the bed of the East River presents many difficulties not encountered under the Hudson. The bottom of the latter waterway is an accumulation of silt, a homogeneous and partially fluid material through which a tunnel shield can be shoved with comparative ease. The soft-ground portion of the East River bottom is a glacial deposit of gravel, mud, and many-sized bowlders the porosity of which makes for a rapid loss of air pressure through the working face and presents the constant hazard of a sudden "blow" which would cause the tunnel to become flooded.

Through more than half of their length, the Queens Midtown tubes cut through rock reefs which lie below the glacial material. Much of this rock does not extend to the roof of the tunnel, necessitating mixed-face excavating, a very slow and tedious operation. Near the Manhattan shore, the tubes pass through a pocket filled with man-dumped debris including a miscellaneous assortment of riprap, bottles, ancient marine hardware, animal skeletons, and other refuse of former days. All the material encountered is of such a nature as to require its removal through the tunnel as the shield progresses. On the other hand, in driving tunnels beneath the Hudson River, the soft silt can be pushed aside.

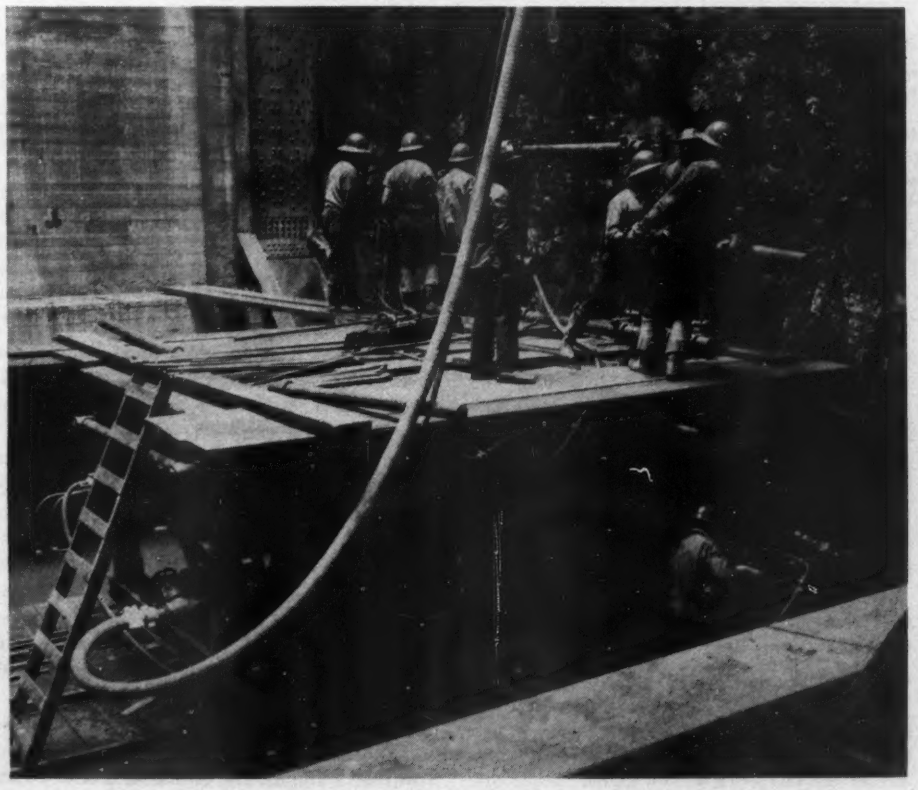
A few words of explanation may be enlightening to readers who are unfamiliar with the compressed-air method of subaqueous construction. To tunnelmen the term "air job" refers to a tunnel or caisson within which it is necessary to maintain air pressure at a point greater than atmospheric in order to counterbalance water pressure from without so as to prevent the workings from being flooded. Most transportation tubes beneath bodies of water are driven under air because limitations in the steepness of the grade usually prevent dropping them deep enough to be entirely in bedrock.

Most compressed-air tunnels are advanced by means of a shield, a massive, cylindrical, steel shell with a cutting edge on the front and of just sufficient diameter so that its rear or trailing edge fits over the outer permanent lining of the bore like a giant thimble. The cast-iron or steel lining is erected within the shield in successive rings; and after a ring of segments has been bolted up, the shield is shoved forward far enough to permit placing the next ring. The tremendous pressure necessary to push the shield through the surrounding muck is supplied by hydraulic jacks mounted on the shield and bearing against the lining behind.

A compressed-air tunnel is safe from flooding if there is a sufficient thickness of muck between its roof and the overlying body of water to prevent the rapid escape of air. Where such a cover does not exist, it has to be provided by dumping clay or other acceptable material on the river bottom above the tunnel line until the necessary protection has been obtained. By the time the driving of the Queens Midtown is completed, a total of 500,000 cubic yards of clay will have been dumped for this purpose, including the re-use of material in the east channel that previously had been placed in the west channel and was then removed by dredging to assure the required navigation depth. Permission had to be procured from the War Department before the existing navigation channels could be shifted and the clay blanket spread.

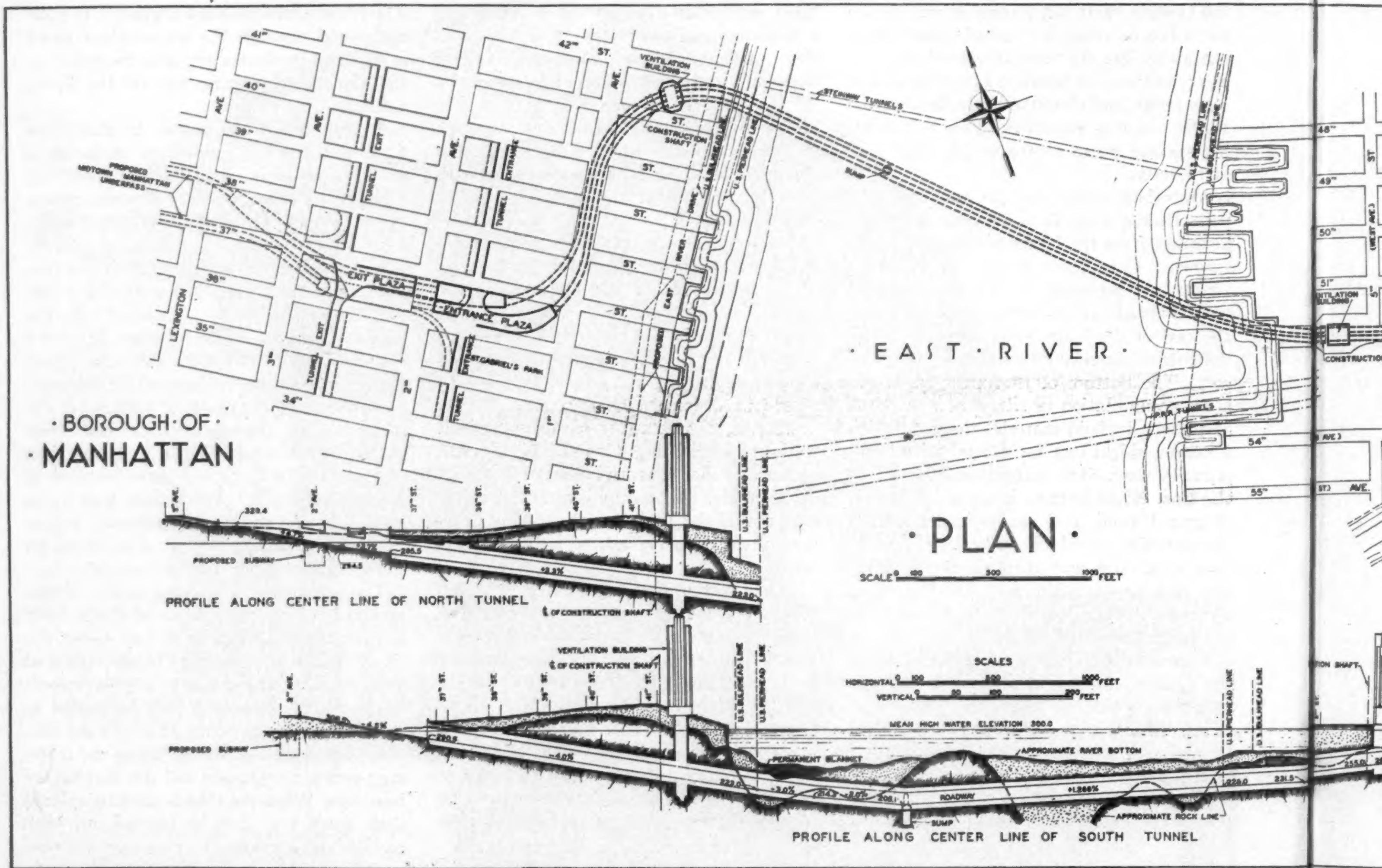
The two tubes are being driven simultaneously from construction shafts on both shores toward a fixed place out under the river. When the headings being advanced from the Manhattan side reach Blackwell's Reef, the tunnel lining will be sealed in the rock and excavating in this solid material continued in free air up to the meeting point of the Queens and the Manhattan headings. When the shields have completed their work they will be burned out with oxyacetylene torches, leaving only the outer skin in position. Under the present construction schedule it is probable that the Manhattan shields will arrive at their destination several months before those from the Queens shore. During this interim the placing of the inner concrete lining can be begun at the Manhattan end. Since this phase of the work is still several months in the future, discussion will be limited to the compressed-air driving operations.

The proper functioning of a shield in an air tunnel is most vital to the success of the job. Failure would be disastrous, because the cost of removing or replacing a damaged shield after the work of driving has been started would be almost prohibitive. Consequently, in designing the four shields for such a tough job, the contractor on the Queens Midtown project spared no expense to obtain the best. Fabricated from heavy, structural-steel members, thick plates, and massive steel castings, each shield unit weighs, when fully equipped, more than 400 tons, has an outside diameter of nearly 32 feet, and an over-all length of 19 feet. The outer shell is 3 inches thick, and consists of laminated steel plates fastened with rivets countersunk and ground flush on the outside to minimize frictional resistance. The front or cutting edge of the shield is made of heavy cast-steel segments. The upper half of the cutting edge overhangs the lower half, thus forming a protective hood beneath which the men work.



STARTING OUT IN ROCK

On both sides of the river were sunk vertical shafts from the bottoms of which the tunnels were started riverward through rock. This picture shows the start of operations from the base of one of the Long Island shafts. Drifters were mounted on a carriage to permit the drilling of a number of holes simultaneously.



GENERAL PLAN, PROFILE, AND SECTIONAL DRAWINGS

Notice the irregularity of the surface of the bedrock in the river bottom, as indicated in the profile sketch. These undulations greatly complicate the task of the tunnel drivers, because they result at many points in a "mixed-face"—that is, a face with the lower part of the heading in rock and the upper part in soft, pervious material. The headings being driven from opposite shores will meet underneath the submerged dome of rock where the word "roadway" appears. The plan drawing shows the great S-like curve in the tunnel line underneath Manhattan by means of which the entrance and exit plazas on that shore are located where they can be linked directly with a proposed underpass beneath the island to join the Lincoln Tunnel, under the Hudson River to the west, with the Queens Midtown.

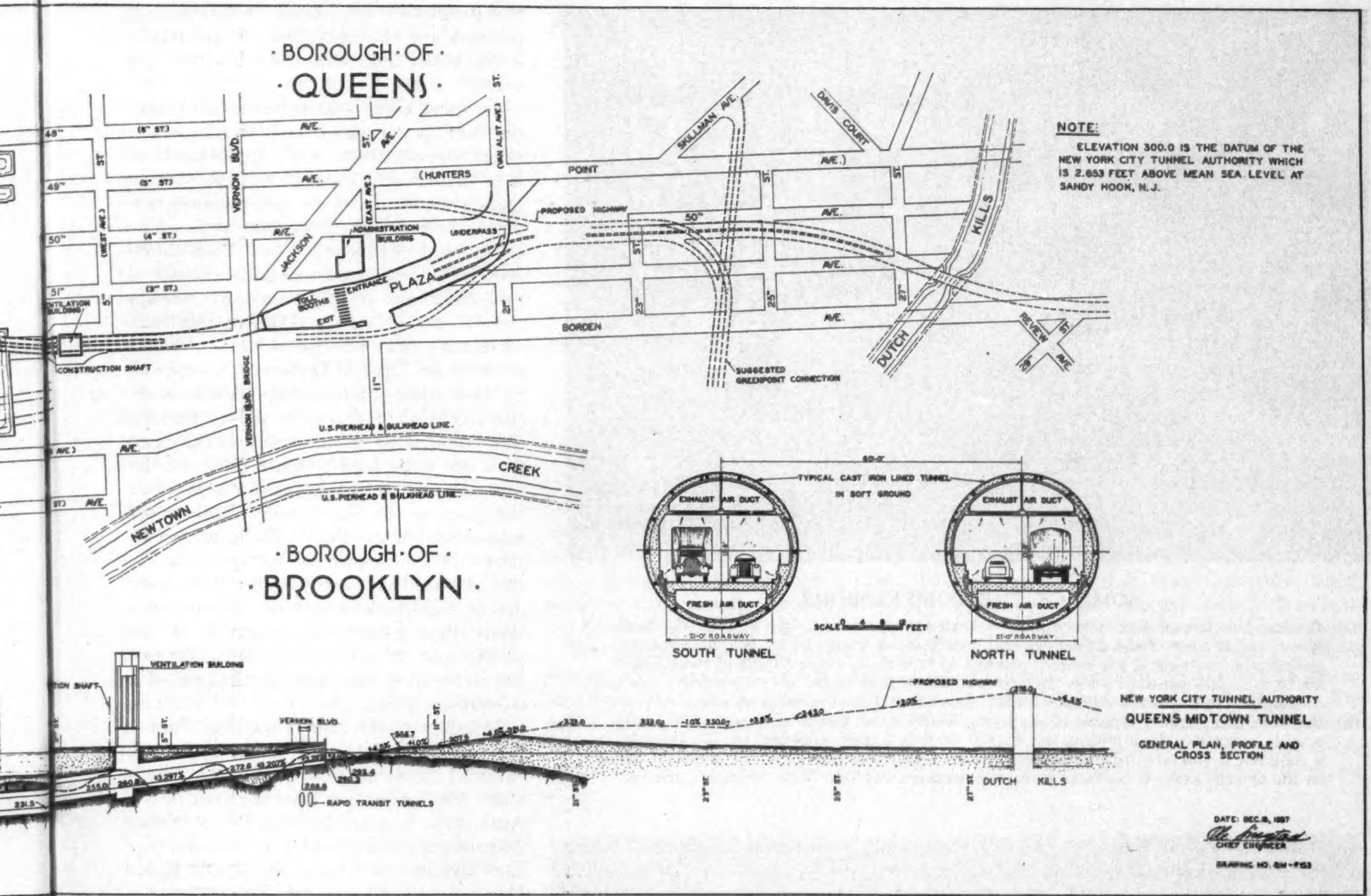
The bracing within the shell is designed so as to provide as much open space as possible through the shield for access to the working face and for removal of the excavated material. The largest of these openings is in the lower half and permits passage of a power shovel through the shield to load material excavated ahead. Built into the bracing at various levels and on the front side of it are a series of movable platforms operated by hydraulic cylinders. These are extensible toward the face and serve as working decks or supports for breast boards in soft ground. On the back of the shield bracing, and pivoted about the center like the hand of a giant clock, is the hydraulically actuated erector arm whose function it is to pick up the segments of cast-iron lining, swing them to any point in the circle, push them into place, and hold them until they can be bolted together. The 28 hydraulic jacks, of 200 tons capacity each, are spaced equidistant around a steel ring girder built into the bracing of the shield.

The tremendous hydraulic pressure—often as high as 5,000 pounds per square inch—required for the operation of the shield units is transmitted through extra-heavy piping from power houses located on the surface near the construction shafts. More will be said later about the power houses and their machinery.

Because of the diversity of the materials encountered under the East River, excavation methods must be varied to suit the ground. When the working face is rock, the procedure is similar to that followed in rock tunneling in free air. Automatic drifter drills are mounted on bars attached to the breast jacks of the shield, holes are drilled, loaded with explosives, and blasted. The machines employed are Ingersoll-Rand DA-35 drifters, supplemented with JA-55 Jackhamers using forge-sharpened drill steel. When the working face is softer material, it is loosened by hand methods with the help of pneumatic chippers and breakers equipped with spades and bull points. The tools mostly employed for this purpose are CC-45 breakers and the smaller L-54 machines. In very soft or treacherous ground it is often necessary to erect a wall of horizontal planking across the front of the shield and to the top of the tunnel. Excavating is a tedious process when using these breast boards, as it means removing one at a time, digging out the material ahead of it, and then replacing it in the new advanced position.

When the nature of the muck permits, it is loaded into cars by means of a Conway power shovel which runs on a 36-inch-gauge haulage track and is equipped with a conveyor belt for transporting the spoil from its dipper to the car behind. The Queens Midtown Tunnel is believed to be the first compressed-air job to utilize this type of shovel, which is widely used in free-air rock tunneling.

When a sufficient quantity of material has been loosened and removed from in front of a shield, the shove is made. This means that pressure is applied to the shield jacks which press backward against the tunnel lining and push the shield forward far enough for the erection of another ring of lining in the rear end of its shell. Control



of the movement of the shield is in the hands of workers, stationed in a niche within the shield bracing, who can, by means of a battery of valves, direct the operation of any one of the several jacking units.

Immediately after the shove has been accomplished, the erecting crew begins placing the next ring of segments which will add another 32 inches to the length of the completed outer lining of the tunnel. The outside diameter of this cast-iron shell is 31 feet, and each ring contains fourteen large segments and a smaller key section all contact surfaces of which are machined to make close-fitting joints. The positions of the longitudinal joints in adjacent rings are staggered. The segments are fastened together with high-tensile-strength steel bolts which are tightened until the steel is stressed nearly to its yield point. Each segment weighs more than 1½ tons, which explains the need for the mechanical erector arm.

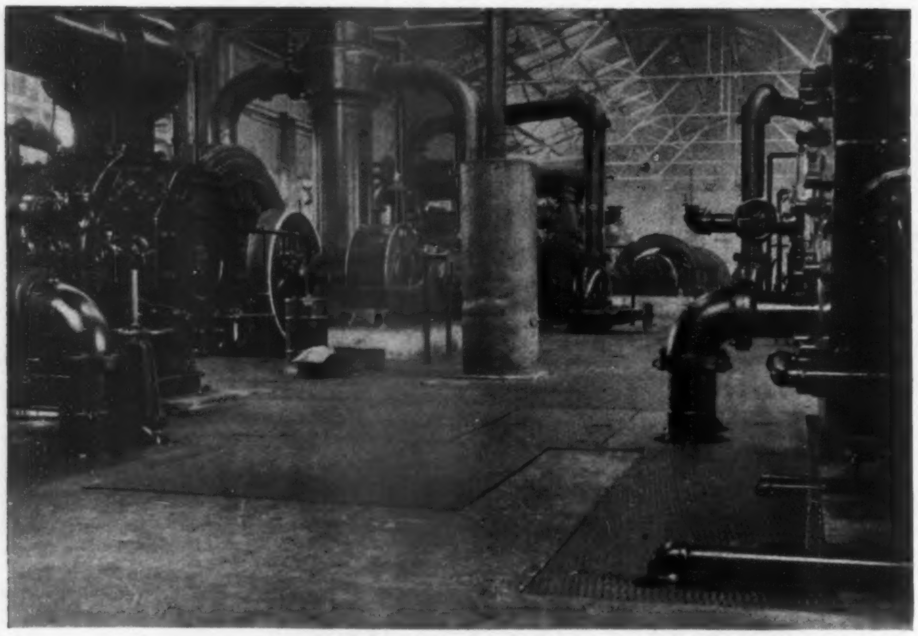
As the shield advances, it draws behind it a working platform in the upper half of the tunnel. This platform, sliding along brackets attached at the spring line, or horizontal center line of the bore, carries equipment and materials for grouting and is also a convenient means of access to the roof of the tunnel. Grouting is done for the purpose of filling the voids between the lining and the surrounding material. The grout consists of sand, cement, and water, and is applied through tapped holes in the cast-iron segments. These openings are tightly plugged as soon as the work is completed.

To lessen the congestion resulting from the many operations performed in the immediate vicinity of the shield, the contractor, with the collaboration of Ingersoll-Rand engineers, developed an ingenious monorail hoist for transferring materials from flat cars to the upper working platform. Suspended on trolleys from an I-beam track in the crown of the tunnel, the machine is powered by two pneumatic motors. Lifting power is supplied by a 4-cylinder K4U Utility hoist unit, and the travel motor is a smaller Type E unit geared directly to the trolley wheels. The operator rides on the machine, being seated on a suspended platform behind the hoist motor. The overhead monorail beam is supported on trolley hangers to enable shifting the track forward as the tunnel heading advances.

Haulage within the tunnels and on the surface in the vicinity of the shafts and storage yards is done by means of electric-storage-battery locomotives running on 36-inch-gauge tracks. Materials entering the tubes are usually on flat cars, while the emerging muck is in steel side-dump cars of 4 cubic yards capacity. Men and materials are lifted from each tunnel to the street level in electrically operated mine cages. Loaded cars of muck are raised in these cages to the top of a muck hopper, about 40 feet above the street level, into which the contents are dumped for withdrawal later into motor trucks and haulage to a place of disposal.

To confine the air pressure within the tunnels, each tube is bulkheaded near the shaft by a 14-foot-thick wall of concrete through which extend the air locks that give access to the interior. These locks are cylindrical steel chambers equipped at each end with airtight doors, the outer one opening into the lock at atmospheric pressure and the inner one giving access to the tunnel after the pressure within the lock has been raised to that maintained in the tunnel. Each bulkhead is penetrated by several of these locks, including a large-diameter one, at the track level, through which pass loaded cars and machinery; one or two smaller locks through which workmen enter and leave the pressure zone; and a still smaller emergency lock, near the top of the tube, which provides a means of escape for the crews should the workings be flooded.

Men entering a lock must undergo a



SOME OF THE COMPRESSORS

Because this tunnel is of larger diameter than any previously driven under the East River, and in view of the difficulties and uncertainties presented by the subterranean geological conditions, it was deemed prudent to provide an ample supply of compressed air to maintain pressure under any circumstances that might be encountered. Accordingly, the engineers stipulated that there should be available at either end of the work compressors capable of supplying 45,000 cubic feet of air per minute at 50 pounds pressure. In addition, air at 100 pounds higher pressure, or 150 pounds, is required to operate drills and tools. Shown here is the interior of the power house on the Queens side. It contains seven low-pressure and two high-pressure machines.

compression period of from two to five minutes. Rapid compression has no harmful effects on persons in normal physical condition. Workers leaving compressed air, however, must be subjected to a considerably longer period of adjustment. The time required for decompression is approximately equal in minutes to the number of pounds pressure per square inch under which the men have been working.

Compressed-air workers, commonly referred to as "sandhogs," may remain under pressure for only a limited period on any one shift, the duration depending upon the pressure to which they are subjected. Whereas a man can work four hours at a stretch under 10 pounds pressure, he may remain under 40 pounds only half an hour at a time. The highest pressure used to date in the Queens Midtown Tunnel is 37½ pounds per square inch. All precautions known to medical science are being taken to counteract the ever-present hazard of compressed-air sickness, known to the men as "bends." On both sides of the river the contractor maintains emergency hospitals with doctors always in attendance and provided with medical locks or decompression chambers for the treatment of afflicted workmen.

The New York City Tunnel Authority engineers—after studying the geological conditions to be encountered in driving the new tunnel, the diameter of which is considerably greater than that of any previously built under the East River—stipulated that, in order to insure the maintenance of pressure in the workings, the contractor's power houses at either end of the job should have sufficient compressor capacity to supply to the tunnel headings 45,000 cubic feet of air a minute at a maximum pressure of 50 pounds. In addition to this unusually high capacity in low-pressure machines, there had to be provided additional units to furnish air at 150 pounds pressure for the operation of pneumatic drills, tools, and motors used within the tunnel.

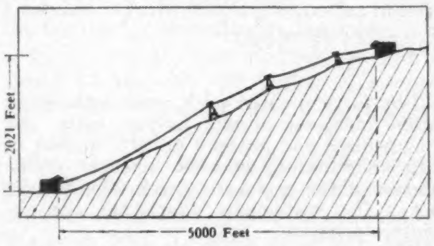
To meet these requirements there have been set up in each of the power houses as impressive an array of big compressors as is to be seen on a construction job. In the Queens plant are seven low-pressure machines and two high-pressure ones. The low-pressure units—all Class PRE 2-cylinder, single-stage compressors—consist of two 28&28x24 units powered by 600-hp. synchronous motors, and of five 29&29x21 machines with 625-hp. motors. High-pressure air, up to 150 pounds, is supplied by two Class PRE 2-stage compressors, size 25&14¼x18, driven by 400-hp. motors. The Manhattan power house is equipped with one more high-pressure unit and the same number of low-pressure machines as the plant on the Queens side. Both power houses also contain the hydraulic machinery that supplies the pressure for operating the tunnel shields. This includes electrically driven high-pressure pumps with accumulators that govern the operation of the pumps and serve much the same purpose that a receiver tank does in the case of a compressor plant.

Members of the New York City Tunnel Authority are Alfred B. Jones, chairman, Albert T. Johnston, and William H. Friedman. Ole Singstad is chief engineer of the Authority. Representing the Public Works Administration is Maurice E. Gilmore, regional director of Region No. 1, and R. H. Keays, project engineer. The contractor for the subaqueous phase of the undertaking is Walsh Construction Company of Davenport, Iowa, of which T. J. Walsh is president, J. H. Gill is vice president, and John S. Macdonald is chief engineer.

SHAFT-HEAD STRUCTURE

Twin cages operated by an electric mine hoist raise the spoils from the two tunnels at this point on Borden Avenue, Long Island City. The workings are about 50 feet below the street level, and the hoppers into which the excavated material is dumped for removal by trucks are situated approximately 40 feet above the street level.

Aerial Tramway Aids Mountain Climbers



ALTHOUGH there are more than 70 aerial passenger tramways in Europe, they are not a familiar means of transportation in North America. There is one at Niagara Falls which carries sight-seers at a height of 150 feet across the Whirlpool Rapids, and another one was placed in operation only last summer. It ascends Cannon Mountain, a 4,107-foot peak in one of the finest scenic sections of New Hampshire. It is approximately one mile in length, and the difference in elevation between its two terminals is 2,021 feet. There are two cars, each of which accommodates 27 passengers and an operator. They travel at a speed of 1,000 feet a minute, or at about the same rate as a modern passenger elevator, and make a 1-way trip in approximately 5½ minutes. By contrast, it takes the average person about 2 hours to climb the mountain by way of the footpath.

In principle, the Cannon Mountain system is similar to the various aerial tramways that have been successfully used for many years in mining sections of this country for transporting ore, supplies, and men over rugged terrain. They are also found in numerous quarries, and in some cases are employed for hauling raw materials to processing plants, such as limestone and clay to cement mills. Another familiar use to which they are put nowadays is to span narrow valleys where dams are under construction.

The New Hampshire installation is technically known as the American-Bleichert-Zuegg Aerial Passenger Tramway system. Each car is suspended from an overhead carriage having eight wheels which travel on a locked-coil steel-wire cable 1⅞ inches in diameter. There is a track cable for each car, the several cables being anchored at each terminal and supported by three intermediate steel towers erected on the mountainside. A 1-inch traction cable, attached to each car, passes around sheaves or groove-rimmed wheels at both terminal stations. It therefore makes a continuous circuit in which the cars are incorporated. By applying power to the sheave at the lower or valley station, the traction cable is caused to move, thus carrying the cars in opposite directions. When one car is at the top of the mountain the other one is at the bottom. The funicular principle of operation applies, the weight of the descending car helping to pull the ascending one and consequently reducing the amount of power required.

As a precaution, an auxiliary traction cable is provided. This is normally strung on top of the towers and out of the way, being held there through tension applied at the mountain-top station. When necessary, this tension can be released by a hand winch and the cable lowered into service position and fastened to either one of two emergency cars stationed at the lower terminal. The car can then be drawn up the mountainside to any desired point. Each regular car carriage is equipped with a brake that is automatically applied should the main traction cable break and that can also be operated in an emergency by the attendant riding in each car. Should the main traction cable fail at any time, the auxiliary cable can be brought into use in the manner just described.

The traction cable is driven by a 100-hp. motor. Direct current for its operation is supplied by a motor-generator set that takes alternating current from a power line. A 60-hp. gasoline engine can be connected by means of a clutch to the direct-current generator to furnish power in the event of a break in the regular service.

The passenger cars are 12-sided and of steel construction, with windows of a transparent synthetic material that serves as windshields in airplanes. Each car contains a telephone for communicating with either terminal station and, in addition, is fitted with a bell system that enables the attendant to send stop or start signals to the operator at the lower terminal. A hatch in the top of each car makes it possible to gain access to the roof for the purpose of connecting the auxiliary traction cable to the carriage should this be necessary. There is also a hatch in the floor through which passengers may be lowered to the ground.

The Cannon Mountain tramway was suggested by Alexander Bright following his return from Europe as a member of the United States Olympic ski team. Funds for its construction were made available by the New Hampshire legislature in June, 1937. It was built under contract by the American Steel & Wire Company, which had previously erected some 700 freight-carrying aerial-tramway systems in North and South America. The electrical equipment was supplied by the Westinghouse Electric & Manufacturing Company. The total cost was approximately $200,000. The tramway is operated the year round and is used during the winter by skiers.

A CAR AT ONE OF THE TOWERS

Freezing Long Used as Aid in Excavating

THE article *Freezing Aids Shaft Excavating* in our January issue brought us three letters of interest, each from a different country. Two of the writers pointed out that the freezing process has been successfully employed for many years. The third correspondent commented on one troublesome phase of the operations described and told how a similar difficulty was avoided in the case of a cofferdam recently sunk under his direction. We quote first from a letter from H. O. Chute, a chemical engineer, of 50 East 41st Street, New York City:

"In your January number there is a description of the freezing method used in preparing the ground for the Gilbertsville Dam. The statement is made that 'this is not the first time this method was used,' although the description would indicate that it is rather uncommon and not well known.

"The writer saw at Iron Mountain, Mich., in the late 80's a deep shaft to iron ore which was dug by a freezing method then patented and widely publicized. As I observed the operation, it was identical with that you described. It might be added that compressed air power was used for operating the refrigeration equipment and for doing some of the other work. Across the street was the Chapin Mine which had 40,000,000 tons of ore in sight, but the shaft sunk by freezing the ground had to go through about 500 feet of muck to reach it. Some years later we deepened this shaft to 1,000 feet.

"The compressed air used was produced by water power and with old-style compression cylinders that had been put in, I believe, in the 70's. The air was piped perhaps 15 miles from Quinnesec Falls to Iron Mountain. When I last saw the plant, it was still running feebly to pump water from the mine. This plant compressed air long before electric current was employed for the same purpose and maintained its usefulness while probably 60,000,000 tons of ore was mined and raised. It served so well over a period of 50 years that it was not displaced by electric power. The air was used for pumping water, running rock drills, operating the hoisting engine, and for many other purposes."

The extensive experience of European engineers and constructors with freezing as an aid to excavating was emphasized in a letter from R. De Maeyer, director and manager of the well-known firm of Foraky in Brussels, Belgium. Messrs. Foraky specialize in shaft-sinking and other underground excavating work. Mr. De Maeyer's letter follows in part:

"We have perused with great interest an article published in your January issue. We congratulate the authors on the success of their undertaking; we wish, however, in the interest of the engineering technique to correct a few statements which are not absolutely accurate.

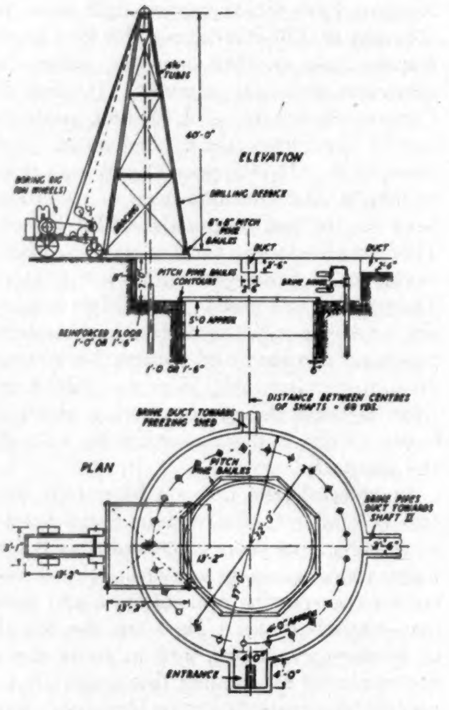
"The second paragraph of the paper leads to the impression that the freezing process is more or less a novelty, in its pioneer stage, and with only a few scattered applications. As a matter of fact, the freezing process has been applied in Europe to the sinking of shafts in loose and heavily water-logged formations for the past 50 years. To our knowledge, more than 200 shafts have been sunk in Great Britain, Germany, Holland, France, Belgium, Poland, etc., the record depth being approximately 2,100 feet.

"Moreover, the authors state that 'literature in the English language contains only meager mention of instances where refrigeration and engineering operations have been co-ordinated.' On the contrary, numerous articles have been published in *Compressed Air Magazine, The Iron and Coal Trades Review, Colliery Engineering, Colliery Guardian, The Engineer*, and other trade magazines.

"Further, the authors state that 'the principal accomplishment of the Gilbertsville refrigeration experiment is that it has demonstrated on a large scale the feasibility of combining earth-freezing with excavating in a practical and advantageous manner.'

"May we state, for the interest of prospective users, that undertakings on a very large scale, namely, the sinking of shafts of diameters up to 70 feet, and to depths as great as 2,000 feet, have been carried out here without the slightest hitch or accident, and it is now admitted that the freezing process has reached the state of perfection."

Accompanying the letter were reprints of an article bearing the title, *The Freezing Process as Applied to Sinking During the Past Ten Years*. This article appeared in



LAYOUT AT WORKINGTON

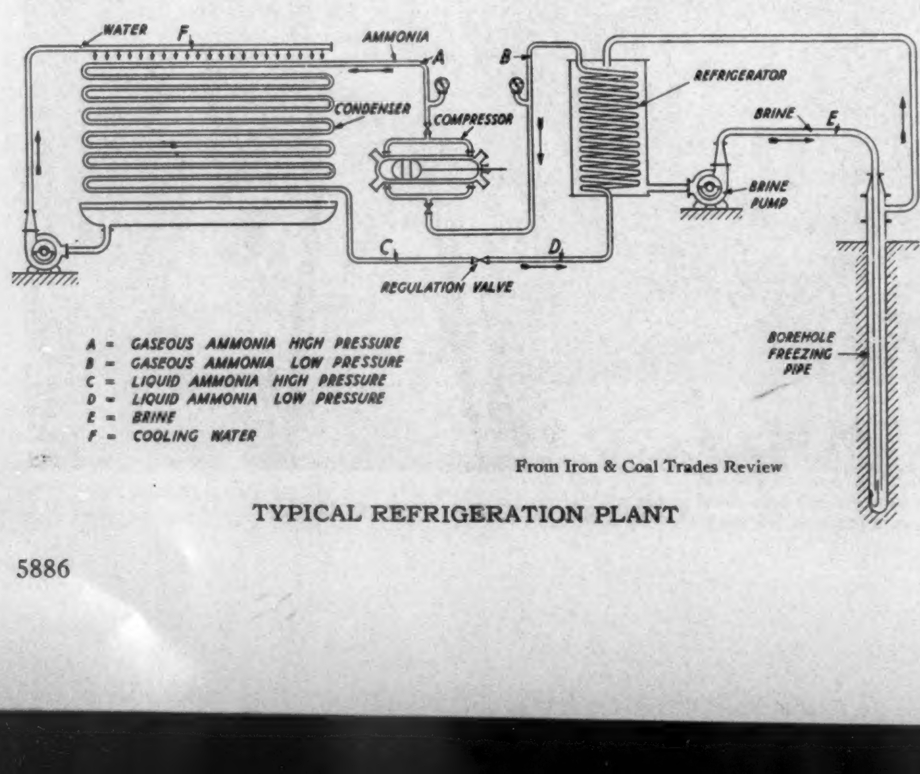
Both freezing and grouting were resorted to in sinking this shaft through water-bearing ground. It was built to tap coal measures.

the November 25, 1938, issue of *The Iron and Coal Trades Review*, a London publication, and was a paper presented by H. E. Mussche and A. Varty at the November 10, 1938, meeting of the Yorkshire Branch of the National Association of Colliery Managers. It reviewed five large-scale excavating undertakings involving the use of refrigeration. One of these—the construction of two tunnels underneath the Scheldt River—was described in detail in the November, 1932, issue of this magazine. A brief outline of the other operations follows:

1—At Houthaelen Colliery, in Belgium, two shafts were sunk to respective depths of 2,106 and 2,140 feet and lined with watertight sheathing, or tubbing, having an aggregate weight of 12,000 tons. Six 300-hp. ammonia compressors supplied the refrigeration.

2—In connection with the building of the King's and Queen's docks at Swansea, Wales, two shafts were sunk. One of them was 236 feet deep, and freezing was resorted to for the first 138 feet. Prior to the application of refrigeration, a sheet-piling cofferdam, 44½x33 feet, was driven and filled with sand to high-tide level.

3—In 1928, Messrs. Foraky sank a shaft with a clear diameter of 15 feet 9 inches to a depth of 580 feet for the Hodbarrow Mining Company, Ltd., of Millom, England. The initial 180 feet was excavated with the aid of freezing, and the successive strata that had to be penetrated were blown sand,



From Iron & Coal Trades Review

TYPICAL REFRIGERATION PLANT

peat, sandy clay, running sand with bowlders, clay, running sand and pebbles. The sea was only 400 feet distant. Down to the 180-foot point, the shaft was lined with tubbing, which was then backfilled with 8 inches of concrete. Twenty freezing holes, each 180 feet deep, were bored in a circle, 22 feet in diameter. Freezing started on April 1, and by August 23 the shaft had been completed and the tubbing, which weighed 253 tons, had been placed. After the ground had thawed, the leakage through the tubbing was found to amount to only 2¾ gallons in 24 hours. The brine with which the freezing was accomplished had an initial temperature of -4°F.

4—In 1937 and 1938, two shafts, each 150 feet deep and 21 feet in finished diameter, were sunk by Messrs. Foraky for the Workington Iron & Steel Company, Ltd. This work involved both grouting and freezing of the ground. The purpose of the shafts was to provide access to coal measures, the tops of which were approximately 100 feet below the surface. A pilot hole was first drilled at the site of each shaft to a depth of 135 feet, or 35 feet into the coal measures. Each hole was lined with 6-inch tubbing which was sealed watertight at the bottom. The holes were then deepened to 225 feet so as to determine how much water would flow into them from the strata below the coal measures. In the first hole, this inflow was found to be at the rate of 1,200 gallons an hour.

At each shaft site there were put down 25 freezing holes, 140 feet deep and arranged in a circle 32 feet in diameter. They were drilled with cable tools and were large enough to accommodate 7-inch casing. Because of the volume of water as revealed by the pilot holes, it was decided to introduce grout prior to freezing, and for this purpose six holes of the 25 at each shaft were selected. These were cased to a depth of 135 feet, sealed off at the bottom, and then deepened to 225 feet. Two injections of grout were made. The initial pressure used for the first application was 60 pounds, and this was gradually increased to 100 pounds. After it had hardened, the cement was rebored and the second injection made under a pressure that was gradually increased from 100 to 200 pounds. After that the water inflow was found to be only 20 gallons an hour. The total quantity of grout introduced was 73 tons in the first shaft and 24 tons in the second one.

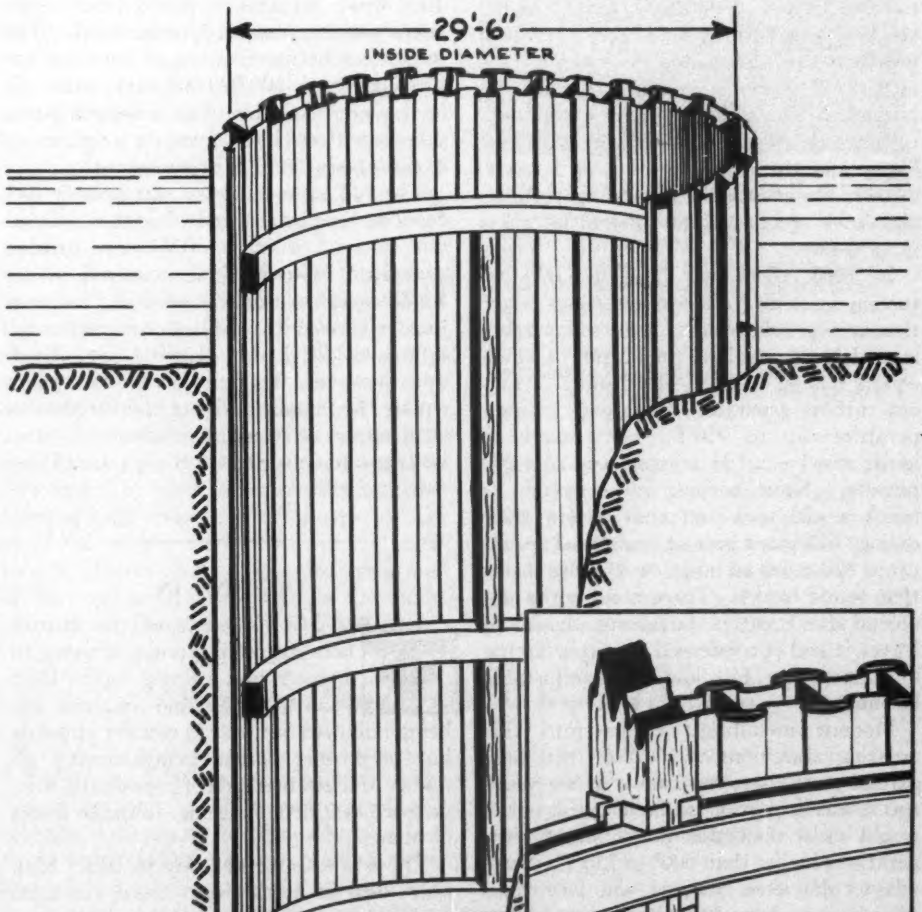
Freezing was started immediately after grouting was completed and was done by circulating brine which had an initial temperature of -4°F. Sinking operations began as soon as it had been determined that a solid encircling ice wall had been formed. When excavating was begun, there was a core 25 feet in diameter that was almost entirely unfrozen, but by the time a depth of 100 feet had been reached, the frost had penetrated to its center. By means of freezing it was possible to sink the shafts without a temporary lining. After they had been excavated to their ultimate depth of approximately 154 feet they were lined with tubbing, and the spaces between it and the walls were backfilled. The tubbing varied in thickness from 1⅛ to 1¾ inches, and was formed with internal flanges for bolting the sections together. Each ring was 5 feet high and 21 feet in diameter, and consisted of sixteen segments. The horizontal and vertical joints were calked with lead. When the contractor turned over the completed work, the leakage through the tubbing was found to be only 0.3 gallon a minute, against a guaranteed minimum of 2 gallons a minute.

According to the authors, the first application of refrigeration to sinking operations in water-bearing ground was made in Wales in 1862. In 1883, a German named Poetsch took out a patent covering a freezing process. Although many successful undertakings embodying the process were carried out prior to the World War, the number increased greatly following the discovery of the Campine Coal Field in northeastern Belgium. In that area the water-bearing formations range from 1,300 to 2,000 feet in thickness. Up to the present time, no satisfactory alternative to freezing prior to shaft-sinking has been found.

Our third correspondent is Charles Davy, bridge engineer for the Canadian National Railways in the central region, with headquarters at Toronto. We quote from his letter:

"From reading the article *Freezing Aids Shaft Excavating*, I would gather that they had considerable difficulty and were put to considerable expense owing to blowouts in the foundations as the excavation got down. The authors state that these blowouts were caused by the interlocking of the steel sheet piling pulling out. I am enclosing a blueprint of a cofferdam that I recently designed and constructed in the gold mining country between Noranda and Senneterre, Quebec. Peculiarly enough, this cofferdam was of exactly the same depth (90 feet) as the one dealt with in the article. By examining the drawing, (see accompanying sketch) you will note that instead of using a single row of steel sheet piling, we drove a double row of this piling with steel 'H' sections driven between the two rows.

"You will be interested to know that we had not the faintest difficulty in excavating this cofferdam to rock. There were no blowouts, there was not an interlock in the whole of the piling broken. It was very economical, as we had no difficulty in salvaging all the outer row of sheet piling and the 'H' sections. The cost of these was merely the cost of their handling, driving, and pulling."



DOUBLE-WALLED COFFERDAM

Details of type of construction used successfully by Canadian National Railways. The inset shows a part of one of the four interior bracing rings.

MORE POWER, LESS COAL

STEAM power plants in the United States produce about twice as much electricity now than they did in 1920, and yet they burn no more coal than they did then. Such has been the improvement in the meanwhile in equipment and in operating practices. Larger generating units, higher steam temperatures, and greater steam pressures are responsible for much of the increase in power output per unit of coal burned. The superposing of "topping" turbines on existing medium-pressure turbines, and the supplementing of noncondensing turbines with condensing turbines also have accounted for substantial gains in economy.

In 1903, there was built a 5,000-kw. turbine generator. It was ten times larger than any previous unit. Yet, today there is in service a machine the output of which equals that of 42 of the 1903 units. Modern turbine generators use steam at temperatures up to 950°F.—hot enough to ignite wood—and at pressures up to 1,200 pounds. Some turbine rotors weigh as much as 20 tons and spin within their casings like giant tops at peripheral speeds up to 820 miles an hour, or 80 miles faster than sound travels. Three-hundredths of a second after it enters the turbine, the steam leaves it and is condensed to water having a temperature too low for comfortable bathing.

Modern metallurgy enters into this amazing development. With the best carbon steel that was known a few years ago it was impossible to build casings that would resist distortion under steam temperatures higher than 600° to 750°F. Nowadays, alloy-steel casings will withstand temperatures from 30 to 60 per cent higher than those just cited without showing any signs of harmful "creep" or permanent stretching.

In order to study the phenomenon of creep, the General Electric Company places rods of turbine materials under tension and holds them, for years at a time, at temperatures which are encountered inside turbines. Measuring gauges disclose changes in length as small as one part in a million. Thus, undesirable materials are eliminated. No harm is done if a turbine changes size from time to time, so long as the changes are symmetrical and uniform and do not exceed one part in a thousand. Just what happens in metal when creep takes place is not well understood. The interstices between atoms of iron are approximately 1/100,000,000 inch wide. It is thought probable that imposed stress pries an atom loose from its neighbor so it can grasp the next atom beyond.

The full significance of this greater fuel economy can be realized when it is pointed out that an average 30,000-kw. turbine generator built in 1918 required about $3,500 worth of coal for each day's operation, whereas its 1939 counterpart runs up a coal bill of only $1,450 a day. Even now, however, the fuel cost for two years equals the installed cost of the turbine, so even minor increases in efficiency in converting coal into electric energy are of far-reaching effect.

DIGGING IN

IN MANY parts of the British Isles there is intense activity in underground mining operations. Vast galleries and caverns are being hollowed out, not to recover minerals but to protect human beings during air raids. Modern methods of conducting warfare are destined, it seems, to make moles of men.

There is a touch of irony in this. Man once lived in a cave, and there was little to distinguish him from other animals. As the result of biological evolution his brain developed, and he emerged into the sunlight and built himself a home aboveground. Then came what we know as civilization, and with it increasing comfort and greater security against the ravages of disease and the attacks of enemies. But with the further development of his creative instinct, man invented powerful explosives, poisonous gases, machine guns, and death-spitting cannons. Then he made the airplane to speed messengers of destruction and terror to far-off places. The circle seems to be completing itself; and now we find mankind digging in again. It all seems unbelievable, and we hope that the world will soon awake and find that it has merely had a bad dream.

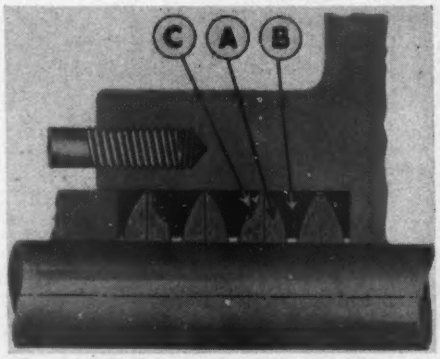
A recent issue of *The Engineer* describes and illustrates the work that is underway at the plant of the Austin Motor Company, in Birmingham, to provide a bombproof shelter for 10,000 persons. It will supplement an already completed burrow that can accommodate 5,000 people. Beneath the track where cars are tested, a series of openings is being driven in sandstone, 55 feet underground. Semicircular headings 17 feet wide and 10 feet high are being advanced, and in the resultant spaces steel arches are being erected and covered over with corrugated steel sheets. Operations are being conducted day and night; and it is expected that the entire system of galleries, requiring the excavating of 18,000 tons of rock, will be completed within a period of ten weeks. The shelters will be entered through sloping passageways. Ventilation will be provided by means of pipes extending up through the ground and rising to a height of 18 feet above the surface where, it is believed, their intakes will be well beyond the reach of concentrations of gas.

The activity at the Austin works is typical of the precautionary measures being taken at all British industrial plants. In many instances, the bombproofs are being located below factory buildings where they will be readily accessible to the workers. Where these are not adequate, additional excavations are being made underneath open areas. In industrial districts, factories are counted upon to give shelter not only to their own employees but to at least a part of the general public in their communities.

Combination Metal and Neoprene Rod Packing

IN MANY plants, the maintenance of rod packing is a routine job to be attended to at infrequent intervals. In others, where service demands are exceptionally severe, it is not unusual to spend a disproportionate amount of time in this work to keep the machines in operating condition. For cases of this kind there has been made available a new type of rod packing by the Rodpak Manufacturing Company.

The product is a combination metal and neoprene—synthetic rubber—packing, the structural parts of which are shown in one of the accompanying illustrations. The shaft seal consists of a group of metal rings which are arranged in sets of two. Of these the contacting faces are flat and the outer faces convex. Depending on the application, they are made either of Babbitt metal or of a metal that will resist a maximum temperature of 700°F. Between these sets of rings are neoprene rings with concave surfaces that fit snugly against the convex faces of the metal rings. Embedded in the rubber are beryllium-copper springs which are seated in recesses in the metal rings. These springs serve a twofold purpose: On centrifugal units they prevent the packing from turning with the shaft, and in the case of reciprocating units they exert an inward and downward pressure that offsets any irregularity in the shaft.



SECTIONAL VIEW

The rod packing consists essentially of metal rings, *A*, which seal the shaft and do not touch the stuffing box; of neoprene rings, *B*, which seal the stuffing box and do not come in contact with the shaft; and of springs, *C*. It provides a floating seal under all conditions.

According to the manufacturer, the new packing has a wide field of application. Its adaptability and unusual features make it suitable for many different kinds of machines that must operate under severe service conditions. It is being employed successfully in pumps handling emulsified asphalt containing a small percentage of caustic soda. These units formerly required packing once a week. Ten months ago they were provided with the metal-and-neoprene rod packing, which is still in use and expected to last again as long, if not longer. In another plant, where hot kerosene is pumped at a pressure ranging from 5,000 to 8,000 pounds per square inch, it was necessary to renew the packing in the pumps every few days. In this case, Rodpak with heat-resisting-metal rings has stood up for eighteen months.

HIGH-PRESSURE COMPRESSOR

Partial view of one frame of a 4-stage Type XRB compressor that is equipped with the new rod packing which lasted ten months before requiring replacement. This is a belt-driven machine that handles a mixture of hydrogen and nitrogen. The picture shows the piston rod in the opening in the distance piece. The packing is in the stuffing box where the rod enters the cylinder on the right.

Paving Breaker Features Air Cushion

AMONG the new and improved products recently announced by Ingersoll-Rand Company is an air-cushioned paving breaker. It is an 80-pound machine and, in addition to the cushioning feature, is said to have an exceptionally large anvil-block bearing to insure proper alignment; an extra-large built-in lubricator; patented, reverse-buttress, self-locking threads on the fronthead bolts and on the latch bolt of the steel retainer to assure tightness without overstraining the bolts; and a valve that increases the tool's power without a proportionate increase in air consumption. By means of a special fronthead and interchangeable steels, the CC-80, or Cushioned Air, can also be used for pile driving, for tamping, for excavating, and for other similar work.

The air cushion is interposed between the anvil block and the piston. It prevents the latter from striking the fronthead and absorbs the blows of the piston when the steel is not in contact with the work. As a result, breakage of wearing parts is reduced to a minimum, and the machine itself is subjected to less shock and is therefore easier to hold, especially when operating at high pressures. An illustrated folder—No. 2530—descriptive of the new paving breaker can be obtained from any of the company's branches or its main office at 11 Broadway, New York, N. Y.

ADAPTABLE TOOL

From left to right: tamping pad, chisel-edge steel, paving breaker with moil-point steel attached, 3x12-inch digging steel, and 5-inch-wide spade.

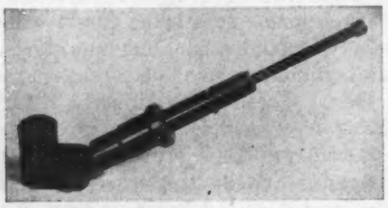
Miniature Steel Mill for Research Man

A STEEL mill in miniature, complete with a 1,500-pound-capacity open-hearth furnace, a 375-pound electric-arc furnace, a 30-pound electric-induction furnace, heat-treating furnaces, rolling mills, and all the other equipment necessary to make steel, has been built at the Pittsburgh, Pa., plant of the Jones & Laughlin Steel Corporation. The making of carbon and alloy steels is a complex job, for around twenty different elements, we are told, enter into their manufacture. Some impart specific properties to the finished product; others rid the metal of impurities or make them harmless; still others counteract injurious oxides or gases; while a fourth group, of which little if any remains in the steel after it has solidified, serves as scavengers.

The mill, which is said to be the first of its kind, is to be used in conjunction with a well-equipped chemical, physical, and metallographic laboratory, and gives the research man the facilities he needs to produce small quantities of steel for test purposes under conditions the same as those existing in large, modern plants where ingots weighing from 3½ to 10 tons are cast.

Industrial Notes

For work in confined areas, where jacks of standard size are too bulky, the Rochester Machine Company has developed a compact, hydraulic jack that weighs 46 pounds and is easy to handle. The tool is built entirely of hardened steel, has an overall height of 6 inches, a lift of 2¾ inches,



a maximum length of 2 feet 8 inches, and requires a minimum space of 5 x 6½ inches for the lifting cylinder. It has a rated capacity of 50 tons, making it suitable for use in moving and lifting heavy machinery and other massive objects where room is limited. To operate the jack, the lifting cylinder is placed under the machine, the long barrel is turned until the plunger comes in contact with the machine, and then the long screw is turned to do the lifting. Conversely, by simply releasing first the screw and then the barrel, the plunger will return to its original position, and the jack can be withdrawn.

A hose retriever that is never in the way has been developed by the Revere Electric Company. It is set underground in a chamber 5 feet deep and 8 inches in diameter and retrieves the hose by gravity. It consists of a housing of galvanized steel with a cast head provided with brass rollers to guide the hose, and can be locked to prevent tampering. The unit is large enough to accommodate 21 feet of ¼-inch air hose and 21 feet of 5/16-inch water hose, and was designed especially for service stations where compressed air and water are in continual use.

An improved method of providing sandhogs with oxygen during the period of decompression has been introduced by the New York City Tunnel Authority. Masks with tube connections are issued to the workers after each shift, and by means of these they are supplied with pure oxygen instead of fresh air, as was formerly the practice. The advantage of this is that the nitrogen taken into the body while under pressure is relieved more rapidly and without the formation in the blood stream of nitrogen bubbles that are the cause of the sickness known as "bends," which is sometimes fatal.

For painting the inside surfaces of pipes, there has been patented abroad a spray gun with an appendant revolving brush that spreads the paint evenly after application. The apparatus is provided with the necessary hose connections and with spring-steel guides that form an ellipse and keep the nozzle centered in its passage through the pipe.

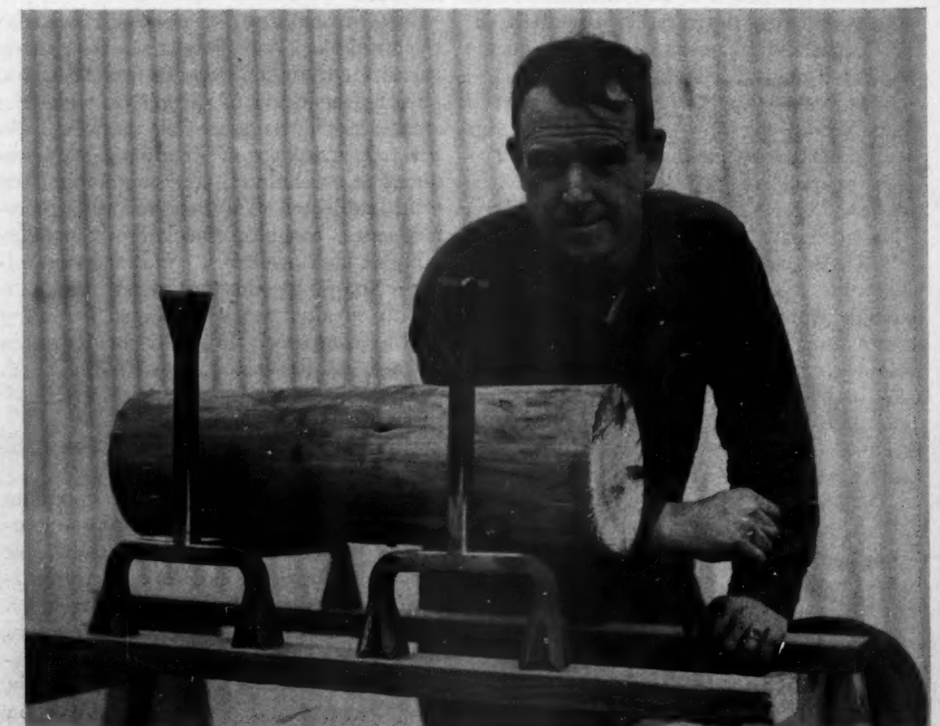
Torkflash is the trade name of a socket wrench that flashes a light when the prescribed tension has been applied to the bolt, nut, stud, or sparkplug being tightened.

Photoelectric tubes must have eagle eyes to be able to detect in a minute every tiny hole in a sheet of thin steel 1 yard wide and long enough to make 5,000 tin cans. The metal races past the tubes at the rate of 700 feet a minute, and yet they catch and conspicuously mark all the holes. Some of them are so minute that they are less than one-third the size of a pin hole, but none escapes the row of vigilant electric eyes.

Serious consideration is again being given to the construction of a railway tunnel to connect Japan and Chosen. The underwater link, even though it is to traverse the narrowest part of Chosen Strait, would have a length of 72 miles and would be carried 180 feet beneath the bottom of the waterway. The preliminary plans call for a tube with a single track and several spurs to permit trains to pass. Subsequently it is to be widened and double-tracked for 2-way traffic.

At the Ford Works in Dagenham, England, where automobile engines are reconditioned under an exchange plan, the work of decarbonizing is being done by a new method that is proving to be a great time saver. Carbon deposits are removed by a stream of fine shot directed against the completely dismantled engine block and cylinder heads placed for the purpose in an encased booth with a heavy plate-glass window. Machined parts are suitably protected against the bombardment. The operator stands outside of the cabinet and applies the shot, which is forced through a rubber hose with compressed air.

Uncleaned gas from blast furnaces is being used as fuel in two new 4-drum, bent-tube-type boilers in the plant of the Dominion Steel & Coal Corporation at Sydney, Nova Scotia. The boilers are rated at 186,000 pounds of steam per hour continuously at 475 pounds pressure when consuming pulverized coal, and 165,000 pounds per hour when burning blast-furnace gas. Coal is used only for starting up the furnaces and when the supply of gas is insufficient. The two boilers consume daily 70,000,000 cubic feet of gas containing approximately 17½ tons of unburnable dust. How this is being disposed of has not been divulged; but the problem it represented has, it is intimated, been solved. By the Heskamp system, by which the gas is cleaned before use, the dust is collected in a specially designed car whence it is blown back into the blast furnaces for resmelting.



ANDIRONS FROM DRILL STEEL

Nate Corley, master mechanic at the Lodestar Mine, Mojave, Calif., is shown with the attractive andirons which he made from pieces of quarter-octagon drill steel that had been worn down in service until they were too short for further use.